FORM PTO-1390 (REV 11-98) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: S004-4257 (PCT)

U S APPLICATION NO (If known, see 37 CFR 1 5): 09/806290

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/JP99/04077	29 JULY 1999(29.07.99)	

TITLE OF INVENTION: MECHANICAL TIME PIECE HAVING BALANCE ROTATIONAL ANGLE CONTROL MECHANISM

APPLICANT(S) FOR DO/EO/US: Takashi TAKAHASHI et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U S.C 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S C. 371
3. [X] This express request to begin national examination procedures (35 U S C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S C 371(b) and PCT Articles 22 and 39(1).
4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date
5. [X] A copy of the International Application as filed (35 U.S C. 371(c)(2))
   a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau)
   b. [X] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [X] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made
8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [ ] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [ ] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [X] Other items or information:

Request
Form PCT/1B/301
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US

U.S. APPLICATION NO (If known, see 37 CFR 1.5) 09/806290	INTERNATIONAL APPLICATION NO PCT/JP99/04077	ATTORNEY'S DOCKET NUMBER S004-4257(PCT)

17. [X] The following fees are submitted:	CALCULATIONS PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):	
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $970.00	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $840.00	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $760.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) $670.00	
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $96.00	
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 860.00
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	6 - 20 =	0	X $18.00	$
Independent claims	1 - 3 =	0	X $78.00	$
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $260.00	$ 270.00
TOTAL OF ABOVE CALCULATIONS =				$ 1130.00
Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).				$
SUBTOTAL =				$ 1130.00
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$
TOTAL NATIONAL FEE =				$ 1130.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$
TOTAL FEES ENCLOSED =				$ 1130.00
			Amount to be: refunded	$
			charged	$

a. [X] A check in the amount of $ 1130.00 to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No _____ in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 01-0268 A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO

Bruce L. Adams, Esq.
Adams & Wilks
50 Broadway-31st Fl.
New York, NY 10004

SIGNATURE

Bruce L. Adams
NAME

25,386
REGISTRATION NUMBER

US

U.S. APPLICATION NO (If known, see 37 CFR 1.5) 09/806290	INTERNATIONAL APPLICATION NO PCT/JP99/04077	ATTORNEY'S DOCKET NUMBER S004-4257(PCT)

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CLAIMS	NUMBER FILED		NUMBER EXTRA	RATE		
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Independent claims	1	- 3 =	0	X $78.00	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)				+ $260.00	$ 270.00	
TOTAL OF ABOVE CALCULATIONS =					$ 1130.00	
Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28)					$	
SUBTOTAL =					$ 1130.00	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)) +					$	
TOTAL NATIONAL FEE =					$ 1130.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +					$	
TOTAL FEES ENCLOSED =					$ 1130.00	
					Amount to be: refunded	$
					charged	$

a. [X] A check in the amount of $ 1130.00 to cover the above fees is enclosed.

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A duplicate copy of this sheet is enclosed

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Bruce L. Adams, Esq.
Adams & Wilks
50 Broadway-31st Fl.
New York, NY 10004

SIGNATURE

Bruce L. Adams
NAME

25,386
REGISTRATION NUMBER

19/PRTS

Description

Mechanical time piece having balance rotational angle control mechanism

[Technical Field]

The present invention relates to a mechanical time piece having a balance rotational angle control mechanism constituted to exert a force for restraining rotation of a balance with hairspring.

[Background of the Invention]

According to a conventional mechanical time piece, as shown in Fig. 18 and Fig. 19, a movement (machine body) 1100 of a mechanical time piece is provided with a main plate 1102 constituting a base plate of the movement. A winding stem 1110 is rotatably integrated to a winding stem guide hole 1102a of the main plate 1102. A dial 1104 (shown in Fig. 19 by an imaginary line) is attached to the movement 1100.

Generally, in both sides of the main plate, a side thereof having the dial is referred to as "back side" of the movement and a side thereof opposed to the side having the dial is referred to as "front side" of the movement. A train wheel integrated to the "front side" of the movement is referred to as "front train wheel" and a train wheel integrated to the "back side" of the movement is referred to as "back train wheel".

A position in the axis line direction of the winding stem 1110 is determined by a switch apparatus including a setting lever 1190, a yoke 1192, a yoke spring 1194 and a setting lever jumper 1196. A winding pinion 1112 is provided rotatably at a guide shaft portion of the winding stem 1110. When the winding stem 1110 is rotated in the state in which the winding stem 1110 is disposed at a first winding stem position (0-stage) on a side most proximate to the inner side of the movement along the rotational axis line, the winding pinion 1112 is rotated via rotation of a clutch wheel. A crown wheel 1114 is rotated by rotation of the winding pinion 1112. A ratchet wheel 1116 is rotated by rotation of the crown wheel 1114. By rotating the ratchet wheel 1116, a mainspring 1122 contained in a barrel complete 1120 is wound up. A center wheel & pinion 1124 is rotated by rotation of the barrel complete 1120. An escape wheel & pinion 1130 is rotated via rotation of a fourth wheel & pinion 1128, a third wheel & pinion 1126 and the center wheel & pinion 1124. The barrel complete 1120, the center wheel & pinion 1124, the third wheel & pinion 1126 and the fourth wheel & pinion 1128 constitute a front train wheel.

An escapement & speed control apparatus for controlling rotation of the front train wheel includes a balance with hairspring 1140, the escape wheel & pinion 1130 and a pallet fork 1142. The balance with hairspring 1140 includes a balance stem 1140a, a balance wheel 1140b and a hairspring 1140c. Based

on rotation of the center wheel & pinion 1124, a cannon pinion 1150 is simultaneously rotated. A minute hand 1152 attached to the cannon pinion 1150 displays "minute". The cannon pinion 1150 is provided with a slip mechanism relative to the center pinion & wheel 1124. Based on rotation of the cannon pinion 1150, via rotation of a minute wheel, an hour wheel 1154 is rotated. An hour hand 1156 attached to the hour wheel 1154 displays "hour".

The barrel complete 1120 is supported rotatably by the main plate 1102 and a barrel bridge 1160. The center wheel & pinion 1124, the third wheel & pinion 1126, the fourth wheel & pinion 1128 and the escape wheel & pinion 1130 are supported rotatably by the main plate 1102 and a train wheel bridge 1162. The pallet fork 1142 is supported rotatably by the main plate 1102 and a pallet bridge 1164. The balance with hairspring 1140 is supported rotatably by the main plate 1102 and a balance bridge 1166.

The hairspring 1140c is a leaf spring in a helical (spiral) shape having a plural turn number. An inner end portion of the hairspring 1140c is fixed to a hairspring holder 1140d fixed to the balance stem 1140a and an outer end portion of the hairspring 1140c is fixed via a hairspring stud 1170a attached to a stud support 1170 fixed to the balance bridge 1166 by fastening screws.

A regulator 1168 is attached rotatably to the balance

bridge 1166. A hairspring bridge 1340 and a hairspring rod 1342 are attached to the regulator 1168. A portion of the hairspring 1140c proximate to the outer end portion is disposed between the hairspring bridge 1340 and the hairspring rod 1342.

Generally, according to a conventional representative mechanical timepiece, as shown by Fig. 14, with elapse of a duration time period of rewinding the mainspring from a state in which the mainspring has completely been wound up (fully wound state), mainspring torque is reduced. For example, in the case of Fig. 14, the mainspring torque is about 27 g·cm in the fully wound state, becomes about 23 g·cm after elapse of 20 hours from the fully wound state and becomes about 18 g·cm after elapse of 40 hours from the fully wound state.

Generally, according to a conventional representative mechanical time piece, as shown by Fig. 15, when the mainspring torque is reduced, the swing angle of the balance with hairspring is also reduced. For example, in the case of Fig. 15, when the mainspring torque is 25-28 g·cm, the swing angle of the balance with hairspring is about 240-270 degree and when the mainspring torque is 20-25 g·cm, the swing angle of the balance with hairspring is about 180-240 degree.

In reference to Fig. 16, there is shown a transitional change of instantaneous rate with regard to swing angle of a balance with hairspring according to a conventional representative mechanical time piece (numerical value

indicating accuracy of time piece). In this case, the "instantaneous rate" is defined as "a value indicating gain or loss of a mechanical time piece after elapse of one day after the mechanical time piece is assumed to be left for one day while maintaining state or environment of swing angle of a balance with hairspring or the like when the rate is measured". In the case of Fig. 16, when a swing angle of a balance with hairspring is equal to or larger than 240 degree or is equal to or smaller than 200 degree, the instantaneous rate is retarded.

For example, according to a conventional representative time piece, as shown by Fig. 16, when the swing angle of the balance with hairspring falls in a range of about 200 through 240 degree, the instantaneous rate is about 0 through 5 seconds / day (gain of 0 through 5 seconds per day), however, when the swing angle of the balance with hairspring is about 170 degree, the instantaneous rate becomes about -20 seconds / day (loss of about 20 seconds per day).

In reference to Fig. 17, there is shown a transitional change of elapse time and instantaneous rate when a mainspring is rewound from a fully wound state in a conventional representative mechanical time piece. In this case, in the conventional mechanical time piece, "rate" indicating gain of the timepiece or loss of the time piece per day, is provided by integrating instantaneous rate with regard to elapse time

of rewinding the balance with hairspring from a fully wound state, which is indicated in Fig. 17 by an extremely slender line, over 24 hours.

Generally, according to the conventional mechanical timepiece, with elapse of duration time period of rewinding the mainspring from the fully wound state, the mainspring torque is reduced, the swing angle of the balance with hairspring is also reduced and accordingly, the instantaneous rate is retarded. Therefore, according to the conventional mechanical timepiece, by estimating loss of the time piece after elapse of the duration time period of 24 hours, instantaneous rate when the mainspring is brought into the fully wound state, is previously gained and previously adjusted such that the "rate" indicating gain of the time piece or loss of the time piece per day becomes positive.

For example, according to the conventional representative time piece, as shown by the bold line in Fig. 17, although in the fully wound state, the instantaneous rate is about 10 seconds / day (gain of about 10 seconds per day), after elapse of 20 hours from the fully wound state, the instantaneous rate becomes about 4 seconds / day (gain of about 4 seconds per day), after elapse of 24 hours from the fully wound state, the instantaneous rate becomes about 0 second per day (no gain and no loss per day) and after elapse of 30 hours from the fully wound state, the instantaneous rate becomes

about -8 seconds / day (loss of about 8 seconds per day).

Further, as a conventional apparatus of adjusting a swing angle of a balance with hairspring, there is disclosed, for example, in Japanese Utility Model Laid-Open No. 41675/1979, a constitution having a swing angle adjusting plate exerting braking force to a balance with hairspring by generating eddy current at each time of pivotal approach of a magnet of the balance with hairspring.

It is an object of the present invention to provide a mechanical time piece having a balance rotational angle control mechanism capable of controlling a swing angle of a balance with hairspring to fall in a constant range.

Further, it is an object of the present invention to provide a mechanical time piece having excellent accuracy in which a change in a rate is inconsiderable even after elapse of an elapse time period from a fully wound state.

[Disclosure of the Invention]

An aspect of the present invention is characterized in a mechanical time piece having a mainspring constituting a power source of the mechanical time piece, a front train wheel rotated by a rotational force when the mainspring is rewound and an escapement & speed control apparatus for controlling rotation of the front train wheel in which the escapement & speed control apparatus is constituted to include a balance

with hairspring alternately repeating right rotation and left rotation, an escape wheel & pinion rotated based on the rotation of the front train wheel and a pallet fork controlling rotation of the escape wheel & pinion based on operation of the balance with hairspring, the mechanical time piece comprising:

a rotational angle control mechanism constituted such that in a state in which the mainspring is completely wound up, air resistance is applied to rotation of a balance with hairspring and in a state in which the mainspring is completely rewound, the air resistance is not applied to the rotation of the balance with hairspring.

It is preferable to construct a constitution in which the balance rotational angle control mechanism includes a resist lever arranged to an outer peripheral portion of the balance with hairspring to provide a clearance therebetween.

Further, it is preferable to construct a constitution in which the balance rotational angle control mechanism includes a planetary gear mechanism related to a barrel complete gear and a ratchet wheel.

It is preferable to construct a constitution in which the resist lever includes a window portion formed by providing the clearance to the outer peripheral portion of the balance with hairspring.

Further, there also can be constructed a constitution in which the resist lever includes arm portions formed by

providing the clearance to the outer peripheral portion of the balance with hairspring.

By using the balance rotational angle control mechanism constituted in this way, rotational angle of the balance with hairspring of the mechanical time piece can effectively be controlled, thereby, accuracy of the mechanical time piece can be promoted.

[Brief Description of the Drawings]

Fig. 1 is a plane view showing an outline shape of a front side of a movement in a state in which a mainspring is rewound according to an embodiment of a mechanical time piece of the invention (in Fig. 1, portions of parts are omitted and bridge members are indicated by imaginary lines).

Fig. 2 is a partial sectional view showing an outline shape of a front train wheel portion according to the embodiment of the mechanical time piece of the invention.

Fig. 3 is a partial plane view showing an outline shape of a portion of a resist lever of the movement in the state in which the mainspring is rewound according to the embodiment of the mechanical time piece of the invention.

Fig. 4 is a partial sectional view showing the outline shape of the portion of the resist lever of the movement in the state in which the mainspring is rewound according to the embodiment of the mechanical time piece of the invention.

Fig. 5 is a block diagram showing operation of the mechanical time piece in the state in which the mainspring is wound up according to the embodiment of the mechanical time piece of the invention.

Fig. 6 is a plane view showing an outline shape of a front side of the movement in the state in which the mainspring is wound up according to the embodiment of the mechanical time piece of the invention (in Fig. 1, portions of parts are omitted and bridge members are indicated by imaginary lines).

Fig. 7 is a partial plane view showing an outline shape of the portion of the resist lever of the movement in the state in which the mainspring is wound up according to the embodiment of the mechanical time piece of the invention.

Fig. 8 is a partial sectional view showing the outline shape of the portion of the resist lever of the movement in the state in which the mainspring is wound up according to the embodiment of the mechanical time piece of the invention.

Fig. 9 is a block diagram showing operation of the time piece in the state in which the mainspring is rewound according to the embodiment of the mechanical time piece of the invention.

Fig. 10 is a plane view showing an outline shape of a front side of a movement in a state in which a mainspring is rewound according to other embodiment of a mechanical time piece of the invention (in Fig. 10, portions of parts are omitted and bridge members are indicated by imaginary lines).

Fig. 11 is a partial plane view showing an outline shape of a portion of a resist lever of the movement in the state in which the mainspring is rewound according to the other embodiment of the mechanical time piece of the invention.

Fig. 12 is a plane view showing an outline shape of a front side of the movement in the state in which the mainspring is rewound according to the other embodiment of the mechanical time piece of the invention (in Fig. 12, portions of parts are omitted and bridge members are indicated by imaginary lines).

Fig. 13 is a partial plane view showing the outline shape of the portion of the resist lever of the movement in the state in which the mainspring is wound up according to the other embodiment of the mechanical time piece of the invention.

Fig. 14 is a graph showing an outline relationship between an elapse time period of rewinding a mainspring from a fully wound state and mainspring torque in a mechanical time piece.

Fig. 15 is a graph showing an outline relationship between a swing angle of a balance with hairspring and mainspring torque in a mechanical time piece.

Fig. 16 is a graph showing an outline relationship between a swing angle of a balance with hairspring and instantaneous rate in a mechanical time piece.

Fig. 17 is a graph showing an outline relationship between an elapse time period of rewinding a mainspring from

a fully wound state and instantaneous rate in a mechanical time piece according to the invention and a conventional mechanical time piece.

Fig. 18 is a plane view showing an outline shape of a front side of a movement of a conventional mechanical time piece (in Fig. 18, portions of parts are omitted and bridge members are indicated by imaginary lines).

Fig. 19 is an outline partial sectional view of the movement of the conventional mechanical time piece (in Fig. 19, portions of parts are omitted).

[Best Mode for Carrying Out the Invention]

An explanation will be given of embodiments of a mechanical time piece according to the invention in reference to the drawings as follows.

In reference to Fig. 1 and Fig. 2, according to an embodiment of a mechanical time piece of the invention, a movement (machine body) 400 of the mechanical time piece is provided with a main plate 102 constituting a base plate of the movement. A winding stem 110 is rotatably integrated to a winding stem guide hole 102a of the main plate 102. A dial 104 (shown in Fig. 2 by imaginary line) is attached to the movement 400.

The winding stem 110 is provided with a square portion and a guide shaft portion. A clutch wheel (not illustrated)

is integrated to the square portion of the winding stem 110. The clutch wheel is provided with a rotational axis line the same as a rotational axis line of the winding stem 110. That is, the clutch wheel is provided with a square hole and is provided to rotate based on rotation of the winding stem 110 by fitting the square hole to the square portion of the winding stem 110. The clutch wheel is provided with tooth A and tooth B. The tooth A is provided at an end portion of the clutch wheel proximate to the center of the movement 400. The tooth B is provided at an end portion of the clutch wheel proximate to an outer side of the movement 400.

The movement 400 is provided with a switch apparatus for determining a position of the winding stem 110 in the axial line direction. The switch apparatus includes a setting lever 190, a yoke 192, a yoke spring 194 and a setting lever jumper 196. Based on rotation of the clutch wheel, the position in the rotational axis line of the winding stem 110 is determined. Based on rotation of the yoke 192, a position in the rotational axis line direction of the setting lever 190 is determined. Based on rotation of the setting lever 190, the yoke 192 is positioned to two positions in the rotational direction.

A winding pinion 112 is provided rotatably at the guide shaft portion of the winding stem 110. When the winding stem 110 is rotated in a state in which the winding stem 110 is disposed at a first winding stem position (0-stage) most

proximate to the inner side of the movement 400 along the rotational axis line, the winding pinion 112 is constituted to rotate via rotation of the clutch wheel. A crown wheel 114 is constituted to rotate by rotation of the winding pinion 112. A ratchet wheel 116 is constituted to rotate by rotation of the crown wheel 114. A click 118 for making rotation of the ratchet wheel 116 one-directional is arranged to be in mesh with a gear portion of the ratchet wheel 116.

The movement 400 is provided with a mainspring 122 contained in a barrel complete 120 as its power source. The mainspring 122 is made of an elastic material having spring performance such as iron. By rotating the ratchet wheel 116, the mainspring 122 is constituted to be capable of being wound up.

A center wheel & pinion 124 is constituted to rotate by rotation of the barrel complete 120. A third wheel & pinion 126 is constituted to rotate based on rotation of the center wheel & pinion 124. A fourth wheel & pinion 128 is constituted to rotate based on rotation of the third wheel & pinion 126. An escape wheel & pinion 130 is constituted to rotate based on rotation of the fourth wheel & pinion 128. The barrel complete 120, the center wheel & pinion 124, the third wheel & pinion 126 and the fourth wheel & pinion 128 constitute a front train wheel.

The movement 400 is provided with an escapement & speed

control apparatus for controlling rotation of the front train wheel. The escapement & speed control apparatus includes a balance with hairspring 140 repeating right rotation and left rotation at a constant period, the escape wheel & pinion 130 rotating based on rotation of the front train wheel and a pallet fork 142 for controlling rotation of the escape wheel & pinion 130 based on operation of the balance with hairspring 140.

The balance with hairspring 140 includes a balance stem 140a, a balance wheel 140b and a hairspring 140c. The hairspring 140c is made of an elastic material having spring performance such as "elinbar". That is, the hairspring 140c is made of an electrically conducting material of metal.

Based on rotation of the center wheel & pinion 124, a cannon pinion 150 is simultaneously rotated. A minute hand 152 attached to the cannon pinion 150 is constituted to display "minute". The cannon pinion 150 is provided with a slip mechanism having a predetermined slip torque relative to the center wheel & pinion 124.

Based on rotation of the cannon pinion 150, a minute wheel (not illustrated) is rotated. Based on rotation of the minute wheel, an hour wheel 154 is rotated. An hour hand 156 attached to the hour wheel 154 is constituted to display "hour".

The barrel complete 120 is supported rotatably by the main plate 102 and a barrel bridge 160. The center wheel & pinion 124, the third wheel & pinion 126, the fourth wheel &

pinion 128 and the escape wheel & pinion 130 are supported rotatably by the main plate 102 and a train wheel bridge 420. The pallet fork 142 is supported rotatably by the main plate 102 and a pallet bridge 164.

The balance with hairspring 140 is supported rotatably by the main plate 102 and a balance bridge 166. That is, an upper mortise 140a1 of the balance stem 140a is supported rotatably by a balance upper bearing 166a fixed to the balance bridge 166. The balance upper bearing 166a includes a balance upper hole jewel and a balance upper cap jewel. The balance upper hole jewel and the balance upper cap jewel are made of an insulating material such as ruby.

A lower mortise 140a2 of the balance stem 140a is supported rotatably by a balance lower bearing 102b fixed to the main plate 102. The balance lower bearing 102b includes a balance lower hole jewel and a balance lower cap jewel. The balance lower hole jewel and the balance lower cap jewel are made of an insulating material such as ruby.

The hairspring 140c is a leaf spring in a helical (spiral) shape having a plural turn number. An inner end portion of the hairspring 140c is fixed to a hairspring holder 140d fixed to the balance stem 140a and an outer end portion of the hairspring 140c is fixed by screws via a hairspring holder 170a attached to a hairspring holder cap 170 rotatably fixed to the balance bridge 166. The balance bridge 166 is

made of an electrically conductive material of metal such as brass. The hairspring holder cap 170 is made of an eclectically conductive material of metal such as iron.

Next, an explanation will be given of operation of the balance with hairspring 140 in reference to Fig. 1 and Fig. 2.

The hairspring 140c is expanded and contracted in a radius direction of the hairspring 140c in correspondence with a rotational angle of rotating the balance with hairspring 140. For example, in a state shown by Fig. 1, when the balance with hairspring 140 is rotated in the clockwise direction, the hairspring 140c is contracted in a direction toward a center of the balance with hairspring 140, in contrast thereto, when the balance with hairspring 140 is rotated in the counterclockwise direction, the hairspring 140c is expanded in a direction remote from the center of the balance with hairspring 140. Incidentally, there may be constructed a structure in which motion of the hairspring 140c is reverse thereto. That is, there can also be constructed a constitution in which when the balance with hairspring 140 is rotated in the counterclockwise direction, the hairspring 140c is contracted in the direction toward the center of the balance with hairspring 140 and when the balance with hairspring 140 is rotated in the clockwise direction, the hairspring 140c is expanded in the direction remote from the center of the balance

with hairspring 140.

Next, an explanation will be given of a balance rotational angle control mechanism of the mechanical time piece according to the invention.

An explanation will be given of a structure of a planetary train wheel mechanism 410 according to an embodiment of the mechanical time piece of the invention in reference to Fig. 1 through Fig. 4.

A first sun wheel 450 is rotatably supported by the train wheel bridge 420 and the main plate 102. The first sun wheel 450 is provided with a first sun gear 452, a first sun pinion 454 and a first sun wheel stem 456. The first sun wheel stem 456 includes a first shaft portion 456a, a second shaft portion 456b and a third shaft portion 456c in a direction from the train wheel bridge 420 to the main plate 102. The first sun gear 452 is disposed at the third shaft portion 456c. The first sun pinion 454 is disposed on a side of the train wheel bridge 420 opposed to a face on the side of the main plate 102, that is, on a side of a case back thereof.

A second sun wheel 460 is rotatably integrated to the first shaft portion 456a of the first sun wheel stem 456. That is, the rotational center of the second sun wheel 460 is the same as the rotational center of the first sun wheel 450. The second sun wheel 460 is provided with a second sun gear 462 and a second sun pinion 464.

A planetary transmission wheel 466 is rotatably supported by a second train wheel bridge 422 and the main plate 102. The second sun gear 462 is in mesh with the planetary transmission wheel 466 and can be rotated by rotation of the planetary transmission wheel 466. The planetary transmission wheel 466 is in mesh with the ratchet wheel 116 and can be rotated by rotation of the ratchet wheel 116.

A planetary intermediate gear 470 is arranged rotatably to the second shaft portion 456b of the first sun wheel stem 456. That is, the rotational center of the planetary intermediate gear 470 is the same as the rotational center of the first sun wheel 450. The planetary intermediate gear 470 is in mesh with a barrel complete gear 120a and can be rotated by rotation of the barrel complete gear 120.

A first planetary wheel 472 is rotatably arranged to the planetary intermediate gear 470 with a portion of the planetary intermediate gear 470 different from the rotational center of the planetary intermediate gear 470 as its rotational center. Further, a second planetary wheel 474 is rotatably arranged to the planetary intermediate gear 470 with a portion of the planetary intermediate gear 470 different from the rotational center of the planetary intermediate gear 470 as its rotational center. That is, the rotational center of the first planetary wheel 472 is the same as the rotational center of the second planetary wheel 474.

The first planetary wheel 472 and the second planetary wheel 474 together constitute a planetary wheel 476 and the both are fixed to each other to be rotatable relative to the planetary intermediate gear 470 in one unit. That is, the first planetary wheel 472 is arranged to be able to rotate by being disposed on a side of the train wheel bridge 420 of the planetary intermediate gear 470, meanwhile, the second planetary wheel 474 is arranged to be able to rotate by being disposed on a side of the main plate 102 of the planetary intermediate gear 170.

The first planetary wheel 472 is in mesh with the second sun pinion 464 and accordingly, the first planetary wheel 472 can be rotated while revolving at a surrounding of the second sun pinion 464. The second planetary wheel 474 is in mesh with the first sun gear 452 and accordingly, the second planetary wheel 474 can be rotated while revolving at a surrounding of the first sun gear 452. Further, the first planetary wheel 472 and the second planetary wheel 474 are constituted to be able to rotate while revolving in one unit.

According to the embodiment of the mechanical time piece of the invention, the speed reduction ratio of the planetary train wheel mechanism 410 is, for example, 1/432.

A resist transmission wheel 480 is rotatably supported by the second train wheel bridge 422 and the train wheel bridge 420. The resist transmission wheel 480 is provided with a

resist transmission gear 482 and a resist transmission pinion 484. The resist transmission gear 482 is provided with two pieces of spring portions and is attached to the resist transmission pinion 484 such that the spring portions can slip relative to the resist transmission pinion 484 by predetermined slip torque. The resist transmission gear 482 is in mesh with the first sun pinion 454 and can be rotated by rotation of the first sun pinion 454.

A resist wheel 486 is rotatably supported by the second train wheel bridge 422 and the train wheel bridge 420. The resist wheel 486 is provided with a resist gear 488. The resist gear 488 is in mesh with the resist transmission pinion 484 and can be rotated by rotation of the resist transmission pinion 484.

A resist wheel degree determining pin 430 is provided to the second train wheel bridge 422. A degree determining portion 432 of the resist wheel degree determining pin 430 is disposed in a notched potion 488c of the resist gear 488. A resist lever 436 is fixed to the resist wheel 486. The resist lever 436 can be rotated by rotation of the resist wheel 486. By positioning the notched portion 488c of the resist gear 488 by the resist wheel degree determining pin 430, rotational angle of the resist gear 488 is restricted to a constant range, thereby, rotational angle of the resist lever 436 is restricted to a constant range.

The resist lever 436 is provided with a resist lever window portion 436a. The resist lever window portion 436a is formed in a circular shape and its inner diameter is formed to be larger than an outer diameter of the balance with hairspring 140. For example, when the outer diameter of the balance with hairspring 140 is 8 millimeters, it is preferable that the inner diameter of the resist lever window portion 436 is 10 millimeters. That is, it is preferable that a clearance SUK in the radius direction between the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 436a falls in a range of 0.8 through 1.2 millimeters (slightly larger or smaller than about 1 millimeter).

A thickness of the resist lever 436 is 1.7 millimeters. A thickness of the balance wheel of the balance with hairspring 140 is 0.8 millimeter. That is, it is preferable that the thickness of the resist lever 436 is formed to be larger than the thickness of the balance wheel.

According to the resist lever 436, a position of a center of the resist lever window portion 436a is positioned to be substantially coincident with the rotational center of the balance with hairspring 140 in a state in which the mainspring is completely rewound. That is, Fig. 1, Fig. 3 and Fig. 4 show a relationship between the resist lever 436 and the balance with hairspring 140 in the state in which the mainspring is

completely rewound. The clearance SUK in the radius direction between the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 436a is determined such that rotation of the balance with hairspring 140 in the state in which the mainspring is completely rewound, is not influenced by the resist lever window portion 436a.

Next, an explanation will be given of operation of the mechanical time piece in winding up the mainspring according to the embodiment of the mechanical time piece of the invention. A rotational direction described below indicates a direction viewing the front side of the movement from the case back side.

In reference to Fig. 3 through Fig. 5, in the state in which the mainspring is completely rewound, by rotation of the wind up train wheel (112, 114), the ratchet wheel 116 is rotated in the clockwise direction. Under the state, rotation of the planetary intermediate gear 470 is restricted by the barrel complete gear 120a and accordingly, the planetary intermediate gear 470 constitutes "fixed gear" in the planetary gear mechanism.

By rotation of the ratchet wheel 116, the planetary transmission wheel 466 is rotated in the counterclockwise direction. By rotation of the planetary transmission wheel 466, the second sun wheel 460 is rotated in the clockwise direction. Since rotation of the planetary intermediate gear 470 is restricted, by rotation of the second sun wheel 460,

the first planetary wheel 472 and the second planetary wheel 474 are rotated in the counterclockwise direction. Rotation of the first planetary wheel 472 and the second planetary wheel 474 is the "rotation" in which the rotational center is not moved.

By rotation of the second planetary wheel 474, the first sun wheel 450 is rotated in the clockwise direction. By rotation of the first sun wheel 450, the resist transmission wheel 480 is rotated in the counterclockwise direction. By rotation of the resist transmission wheel 480, the resist gear 488 is rotated in the clockwise direction. When the resist gear 488 is rotated in the clockwise direction, at the same time, the resist lever 436 is rotated in the clockwise direction.

Therefore, by winding up the mainspring, the resist lever 436 is rotated in the clockwise direction from a state shown by Fig. 3.

By further winding up the mainspring, the resist lever 436 is further rotated in the clockwise direction and a state shown by Fig. 6 through Fig. 8 is produced. The state shown by Fig. 6 through Fig. 8 is a "fully wound" state of the mainspring. A position of the resist lever 436 under the state is restricted by positioning the notched portion 488c of the resist wheel 488 by the resist wheel degree determining pin 430.

In the state shown by Fig. 6 through Fig. 8, it is preferable that the clearance SUM at portions of the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 436a minimizing the clearance in the radius direction therebetween, falls in a range of 0.1 through 0.2 millimeter.

The clearance SUM in the radius direction between the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 436a, is determined such that in such a state in which the mainspring is completely wound up ("fully wound" state), rotation of the balance with hairspring 140 is attenuated by being influenced by the resist lever window portion 436a. That is, in the state shown by Fig. 6 through Fig. 8, flow of air disposed between the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 436a, undergoes a resistance by the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 436a and a force for restraining rotation of the balance with hairspring 140 is exerted to the balance with hairspring 140.

Next, an explanation will be given of operation of the time piece when the mainspring is rewound, that is, when the mechanical time piece displays time according to the embodiment of the mechanical time piece of the invention.

In reference to Fig. 7 through Fig. 9, the barrel

complete gear 120a is rotated and time is displayed. At this occasion, the barrel complete gear 120a is rotated in the clockwise direction.

Under the state, by operation of the click 118 engaged with the gear of the ratchet wheel 116, rotation of the ratchet wheel 116 is restricted and therefore, rotation of the planetary transmission wheel 466 is also restricted and the second sun wheel 460 constitutes the "fixe gear" in the planetary gear mechanism.

By rotation of the barrel complete gear 120a, the planetary intermediate gear 470 is rotated in the counterclockwise direction. Since rotation of the second sun wheel 460 is restricted, by rotation of the planetary intermediate gear 470, the first planetary wheel 472 is rotated while revolving at the surrounding of the second sun pinion 464. Since the first planetary wheel 472 and the second planetary wheel 474 are integrated, the second planetary wheel 474 is rotated while revolving at the surrounding of the first sun gear 452.

Under the state, the first planetary wheel 472 and the second planetary wheel 474 are rotated in the counterclockwise direction. Rotation of the first planetary wheel 172 and the second planetary wheel 174 constitute "planetary motion" in which the rotational center is varied. For example, according to the embodiment of the mechanical time piece of the invention,

the train wheel reduction ratio is 1/2.

By rotation of the second planetary wheel 474 and the planetary intermediate gear 470, the first sun wheel 450 is rotated in the counterclockwise direction. By rotation of the first sun wheel 450, the resist transmission wheel 480 is rotated in the clockwise direction. By rotation of the resist transmission wheel 480, the resist gear 488 is rotated in the counterclockwise direction. When the resist gear 488 is rotated in the counterclockwise direction, at the same time, the resist lever 436 is rotated in the counterclockwise direction.

Therefore, by rewinding the mainspring, the resist lever 436 is rotated in the counterclockwise direction from the state shown by Fig. 7.

By further rewinding the mainspring, the resist lever 436 is further rotated in the counterclockwise direction and the state shown by Fig. 1 through Fig. 4 is produced. The state shown by Fig. 1 through Fig. 4 is the state in which the mainspring is completely rewound. The position of the resist lever 436 under the state, is restricted by positioning the notched portion 480c of the resist gear 488 by the resist wheel degree determining pin 430.

Therefore, according to the embodiment of the mechanical time piece of the invention, the clearance in the radius direction between the outer peripheral portion of the

balance with hairspring 140 and the resist lever window portion 436a is constituted such that the clearance is the smallest in the state in which the mainspring is completely wound up ("fully wound" state) and the largest in the state in which the mainspring is completely rewound. Further, it is determined that in the state in which the mainspring is completely wound up ("fully wound" state), rotation of the balance with hairspring 140 is attenuated by being mostly influenced by the resist lever window portion 436a. That is, the flow of air disposed between the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 436a, undergoes the largest resistance by the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 436a in the state in which the mainspring is completely wound up ("fully wound" state) and exerts the largest force for restraining rotation of the balance with hairspring 140 to the balance with hairspring 140.

Further, by rewinding the mainspring from the state in which the mainspring is completely wound up ("fully wound" state), the resistance which the flow of air disposed between the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 436a undergoes, is reduced and when the mainspring is completely rewound, the resistance is eliminated.

According to the mechanical time piece of the invention

constituted in this way, the rotational angle of the balance with hairspring 140 can efficiently be controlled.

Next, an explanation will be given of other embodiment of a mechanical time piece according to the invention.

In reference to Fig. 10, according to other embodiment of a mechanical time piece of the invention, a movement (machine body) 490 of a mechanical time piece is provided with a main plate 102T constituting a base plate of the movement. The outer diameter dimension of the main plate 102T is smaller than the outer diameter dimension of the main plate 102.

A resist lever 496 is fixed to a resist wheel 486. The resist lever 436 can be rotated by rotation of the resist wheel 486. The resist lever 496 is provided with a first arm 496a and a second arm 496b.

In reference to Fig. 10 and Fig. 11, the resist lever 496 is provided with a resist lever window portion 496c. The resist lever window portion 496c is constituted by a shape in correspondence with a portion of a circle and the inner diameter is formed to be larger than the outer diameter of the balance with hairspring 140. For example, when the outer diameter of the balance with hairspring 140 is 8 millimeters, it is preferable that the inner diameter of the resist lever window portion 496c is 10 millimeters. That is, it is preferable that the clearance SUK in the radius direction between the outer peripheral portion of the balance with hairspring 140 and the

resist lever window portion 496c, falls in a range of 0.8 through 1.2 millimeters (slightly larger or smaller than about 1 millimeter).

The thickness of the resist lever 496 is 1.7 millimeters. The thickness of the balance wheel of the balance with hairspring 140 is 0.8 millimeter. That is, it is preferable that the thickness of the resist lever 496 is formed to be larger than the thickness of the balance wheel.

According to the resist lever 496, the position of the center of the resist lever window portion 496c is positioned to be substantially coincident with the rotational center of the balance with hairspring 140 in the state in which the mainspring is completely rewound. That is, Fig. 10 and Fig. 11 show a relationship between the resist lever 496 and the balance with hairspring 140 in the state in which the mainspring is completely rewound. The clearance SUK in the radius direction between the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 496c, is determined such that rotation of the balance with hairspring 140 in the state in which the mainspring is completely rewound, is not influenced by the resist lever window portion 496c.

Structure of other portion in the other embodiment of the mechanical time piece of the invention, is similar to the structure in the embodiment of the mechanical time piece of the invention described above in reference to Fig. 1 through

Fig. 9.

According to the other embodiment of the mechanical time piece of the invention, by winding up the mainspring, the resist lever 496 is rotated in the clockwise direction from a state shown by Fig. 10 and Fig. 11.

By further winding up the mainspring, the resist lever 496 is further rotated in the clockwise direction and a state shown by Fig. 12 and Fig. 13 is produced. The state shown by Fig. 12 and Fig. 13 constitutes the "fully wound" state of the mainspring.

In the state shown by Fig. 12 and Fig. 13, it is preferable that the clearance SUM of portions of the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 496c minimizing the clearance in the radius direction therebetween, falls in a range of 0.1 through 0.2 millimeter.

The clearance SUM in the radius direction between the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 496c, is determined such that rotation of the balance with hairspring 140 is attenuated by being influenced by the resist lever window portion 496c in the state in which the mainspring is completely wound up ("fully wound" state). That is, in the state shown by Fig. 12 and Fig. 13, the flow of air disposed between the outer peripheral portion of the balance with hairspring 140 and the

resist lever window portion 496c, undergoes a resistance by the outer peripheral portion of the balance with hairspring 140 and the resist lever window portion 496c and exerts a force for restraining rotation of the balance with hairspring 140 to the balance with hairspring 140.

Other operation in the other embodiment of the mechanical time piece of the invention, is similar to operation in the embodiment of the mechanical time piece of the invention previously described in reference to Fig. 1 through Fig. 9.

As has been explained above, the invention is constructed by the constitution having the balance rotational angle control mechanism in the mechanical time piece constituted such that the escapement & speed control apparatus includes the balance with hairspring repeating right rotation and left rotation, the escape wheel & pinion rotated based on rotation of the front train wheel and the pallet fork for controlling rotation of the escape wheel & train based on operation of the balance with hairspring and accordingly, the accuracy of the mechanical time piece can be promoted without reducing the duration time period of the mechanical time piece.

That is, according to the invention, attention is paid to the correlation between the instantaneous rate and the swing angle, by maintaining constant the swing angle, the change in the instantaneous rate is restrained and the time piece is adjusted such that gain or loss of the time piece per day is

reduced.

In contrast thereto, according to the conventional mechanical time piece, the swing angle is changed with elapse of time by the relationship between the duration time period and the swing angle. Further, by the relationship between the swing angle and the instantaneous rate, the instantaneous rate is changed with elapse of time. Therefore, it has been difficult to prolong the duration time period of the time piece capable of maintaining constant accuracy.

Next, an explanation will be given of a result of a simulation with respect to the mechanical time piece of the invention which is developed to resolve the problem of the conventional mechanical time piece.

In reference to Fig. 17, according to the mechanical time piece of the invention, in the state in which the mainspring is completely wound up, the rate is about 10 seconds / day (gain of about 10 seconds per day), after elapse of 20 hours from the fully wound state, the instantaneous rate becomes about 7 seconds / day (gain of about 7 seconds per day) and after elapse of 30 hours from the fully wound state, the instantaneous rate becomes about -3 seconds / day (loss of about 3 seconds per day).

In contrast thereto, according to the conventional mechanical time piece, in the state in which the mainspring is completely wound up, the rate is about 10 seconds / day (gain

of about 10 seconds per day), after elapse of 20 hours from the fully wound state, the instantaneous rate becomes about 4 seconds / day (gain of about 4 seconds per day) and after elapse of 30 hours from the fully wound state, the instantaneous rate becomes about -8 seconds / day (loss of about 8 seconds per day).

According to the mechanical time piece having the balance rotational angle control mechanism of the invention, by controlling the swing angle of the balance with hairspring, the change in the instantaneous rate of the time piece is restrained and therefore, in comparison with the conventional mechanical time piece, an elapse time period from the fully wound state in which the instantaneous rate is about 0 through 10 seconds / day can be maintained longer.

That is, according to the mechanical time piece of the invention, a duration time period in which the instantaneous rate falls in a rage of about 0 through 10 seconds / day is about 28 hours. According to the conventional mechanical time piece, a duration time period in which the instantaneous rate falls in the range of about 0 through 10 seconds / day is about 24 hours. Therefore, according to the mechanical time piece of the invention, the duration time period in which the change in the rate falls within 10 seconds / day can be made about 1.2 times as much as that of the conventional mechanical time piece.

Therefore, there is provided the result of the simulation in which the mechanical time piece according to the invention is very accurate in comparison with the conventional mechanical time piece.

[Industrial Applicability]

The mechanical time piece according to the invention is provided with the simple structure and is suitable for realizing a mechanical time piece having very excellent accuracy.

Claim(s)

1. A mechanical time piece characterized in that in a mechanical time piece having a mainspring constituting a power source of the mechanical time piece, a front train wheel rotated by a rotational force when the mainspring is rewound and an escapement & speed control apparatus for controlling rotation of the front train wheel in which the escapement & speed control apparatus is constituted to include a balance with hairspring alternately repeating right rotation and left rotation, an escape wheel & pinion rotated based on the rotation of the front train wheel and a pallet fork controlling rotation of the escape wheel & pinion based on operation of the balance with hairspring, said mechanical time piece comprising:

a rotational angle control mechanism constituted such that in a state in which the mainspring is completely wound up, air resistance is applied to rotation of a balance with hairspring (140) and in a state in which the mainspring is completely rewound, the air resistance is not applied to the rotation of the balance with hairspring (140).

2. The mechanical time piece according to Claim 1, characterized in that the balance rotational angle control mechanism includes a resist lever (436, 496) arranged to an outer peripheral portion of the balance with hairspring (140) to provide a clearance therebetween.

3. The mechanical time piece according to Claim 1 or

2, characterized in that the balance rotational angle control mechanism includes a planetary gear mechanism (410) related to a barrel complete gear (120a) and a ratchet wheel (116).

4. The mechanical time piece according to Claim 2, characterized in that the resist lever (436) includes a window portion (436a) formed by providing the clearance to the outer peripheral portion of the balance with hairspring (140).

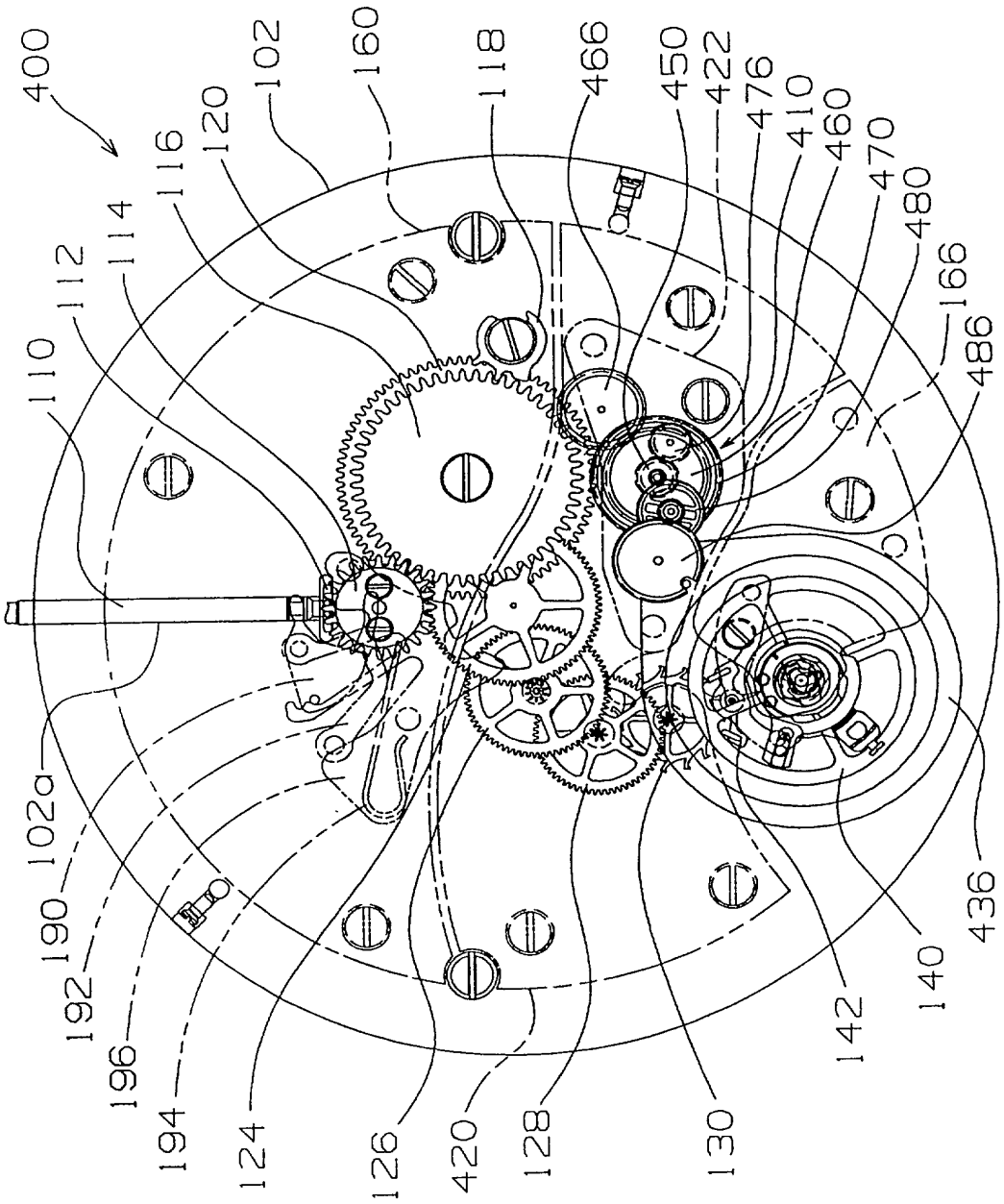
5. The mechanical time piece according to Claim 2, characterized in that the resist lever (496) includes arm portions (496a, 496b) formed by providing the clearance to the outer peripheral portion of the balance with hairspring (140).

Abstract

In a mechanical time piece according to the invention, a movement 400 includes a barrel complete 120, a center wheel & pinion 124, a third wheel & pinion 126, a fourth wheel & pinion 128, a balance with hairspring 140, an escape wheel & pinion 130 and a pallet fork 142. The mechanical time piece of the invention is provided with a rotational angle control mechanism constituted such that in a state in which a mainspring is completely wound up, air resistance is applied to rotation of the balance with hairspring 140 and in a state in which the mainspring is completely rewound, the air resistance is not applied to the rotation of the balance with hairspring 140. The balance rotational control mechanism includes a resist lever 436, 496 arranged to an outer peripheral portion of the balance with hairspring 140 to provide a clearance therebetween.

Further, the balance rotational angle control mechanism is characterized in including a planetary gear mechanism 410 related to a barrel complete gear 120a and a ratchet wheel 116.

FIG. 1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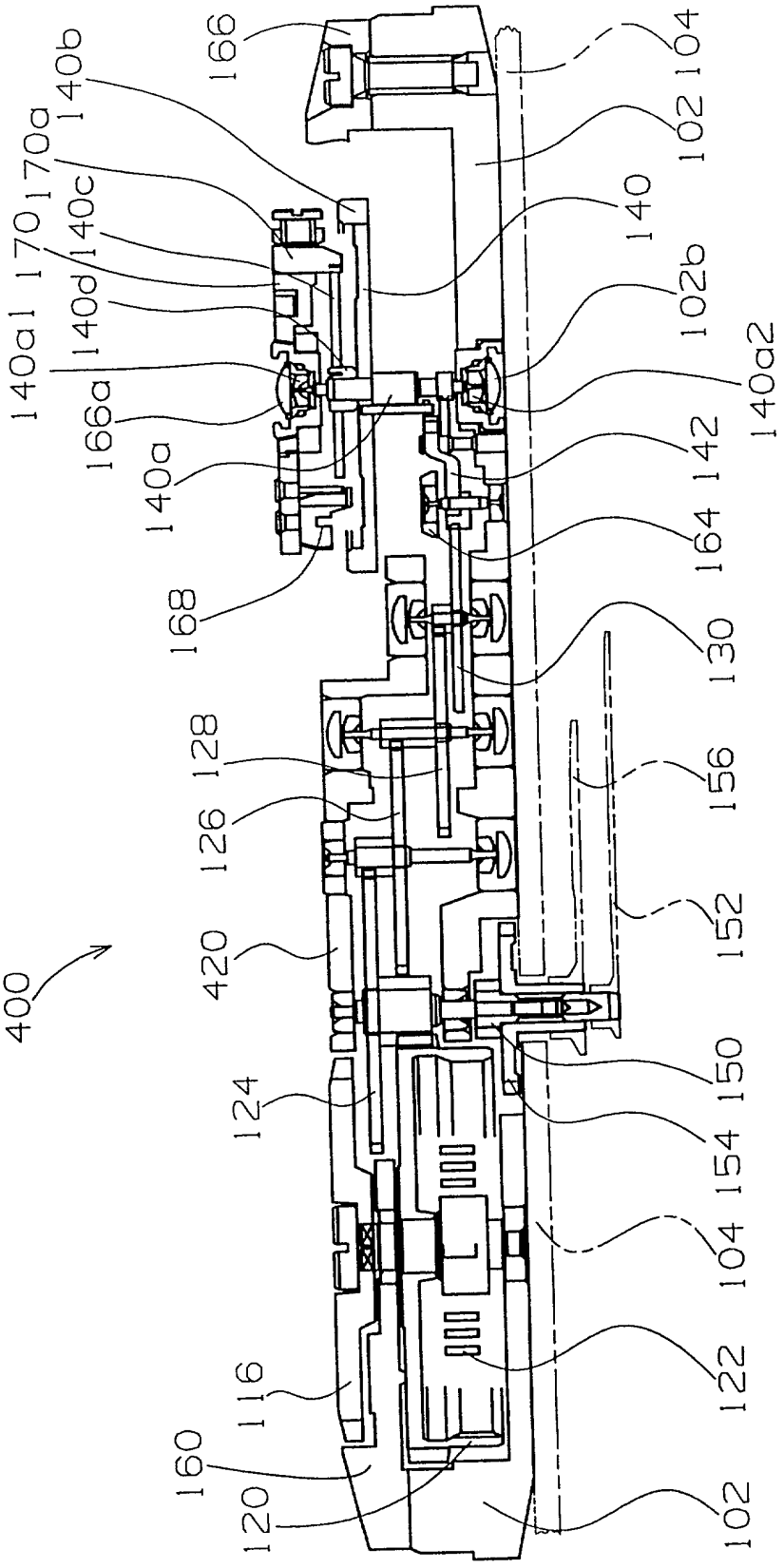
160
118
466
450
422
476
410
460
470
480
166
486
436
140
142
130
128
420
126
124
194
196
192
190
102a
110
112
114
116
120

FIG. 2


166
104
102
140b
170a
140c
140
170
140d
102b
140a1
166a
140a2
140a
142
164
168
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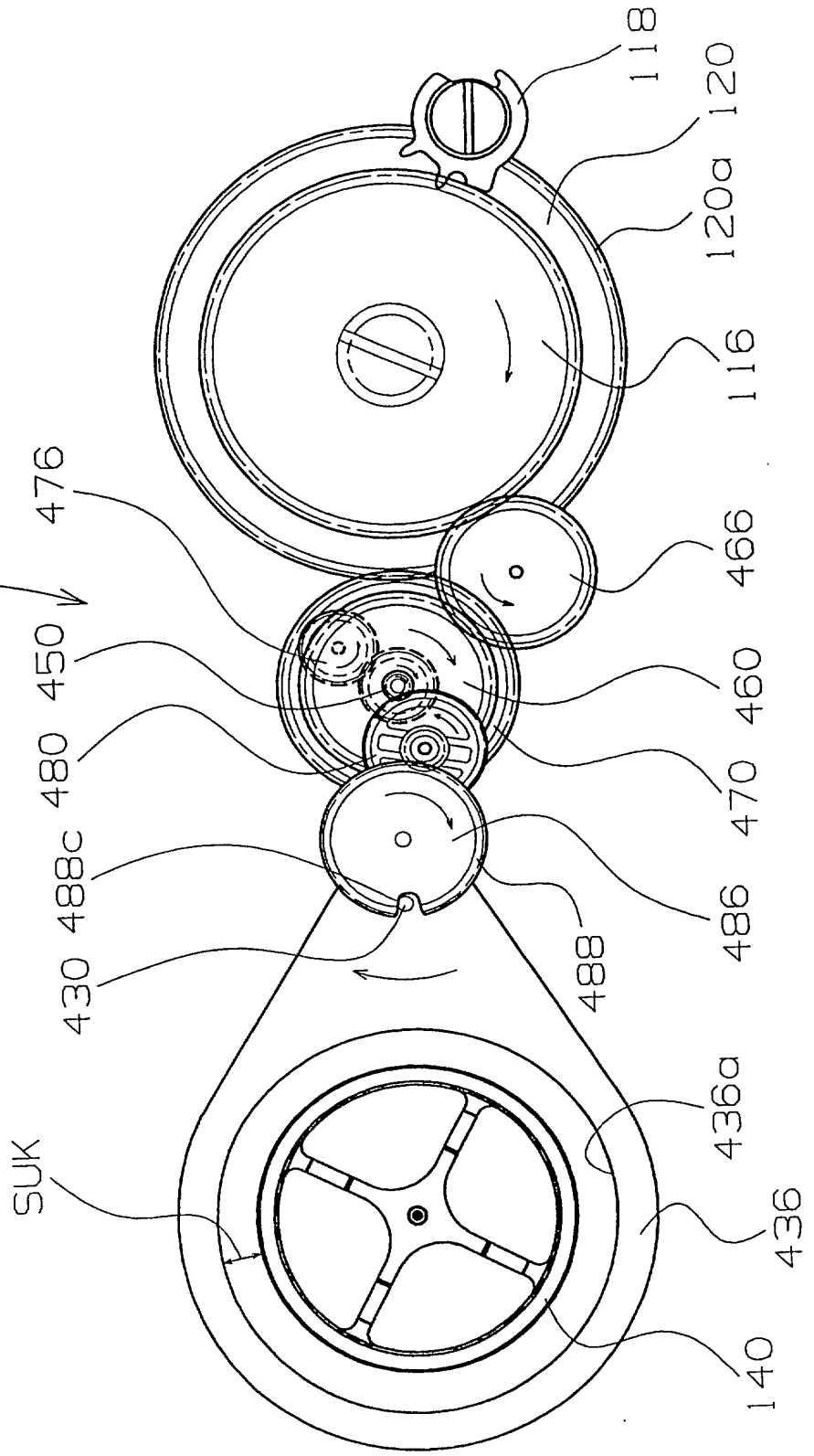
128
156
126
152
420
400
150
124
154
104
122
116
160
120
102

FIG. 3


118
120
120a
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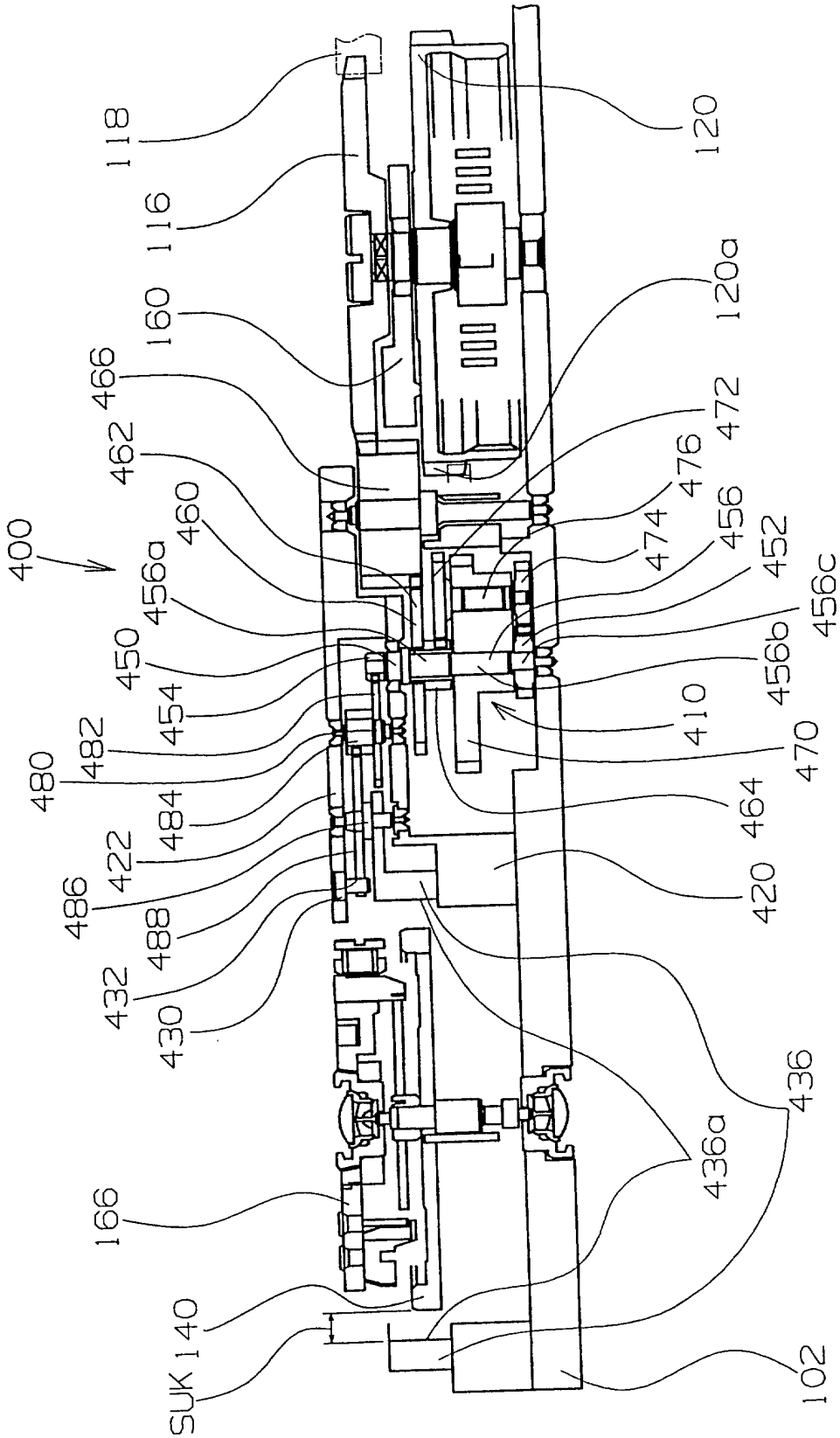
476
466
410
450
460
480
470
488c
486
430
488
436a
SUK
436
140

FIG. 4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116
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466
462
460
400
456a
450
454
482
480
484
422
486
488
432
430
166
SUK 140
120
120a
472
476
474
456
452
456c
456b
410
470
464
420
436
436a
102

FIG.5

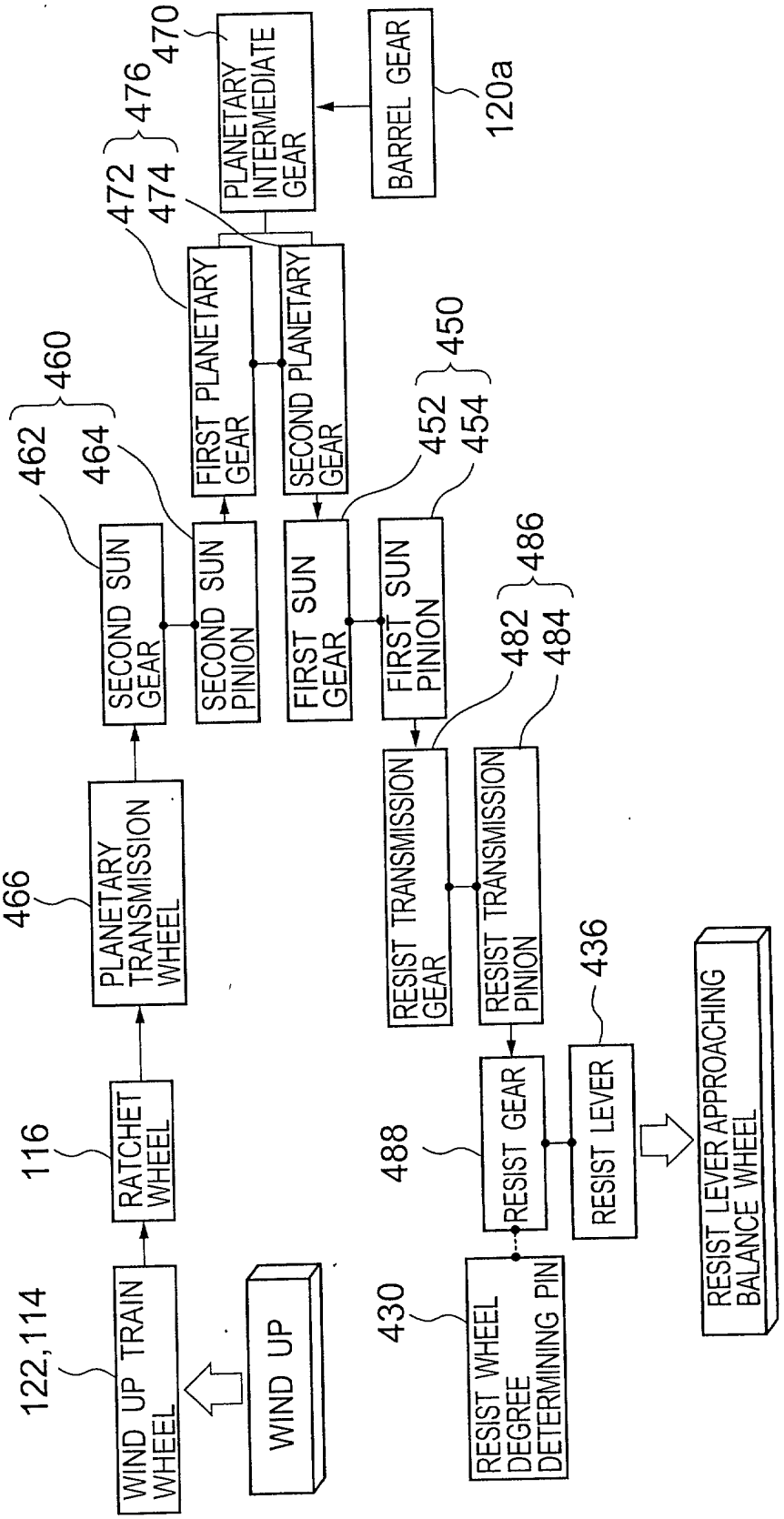

122,114
WIND UP TRAIN WHEEL
WIND UP
116
RATCHET WHEEL
466
PLANETARY TRANSMISSION WHEEL
462
SECOND SUN GEAR
464
SECOND SUN PINION
460
472
474
476
FIRST PLANETARY GEAR
SECOND PLANETARY GEAR
470
PLANETARY INTERMEDIATE GEAR
BARREL GEAR
120a
452
454
450
FIRST SUN GEAR
FIRST SUN PINION
482
484
486
RESIST TRANSMISSION GEAR
RESIST TRANSMISSION PINION
436
488
RESIST GEAR
RESIST LEVER
430
RESIST WHEEL DEGREE DETERMINING PIN
RESIST LEVER APPROACHING BALANCE WHEEL

FIG. 6

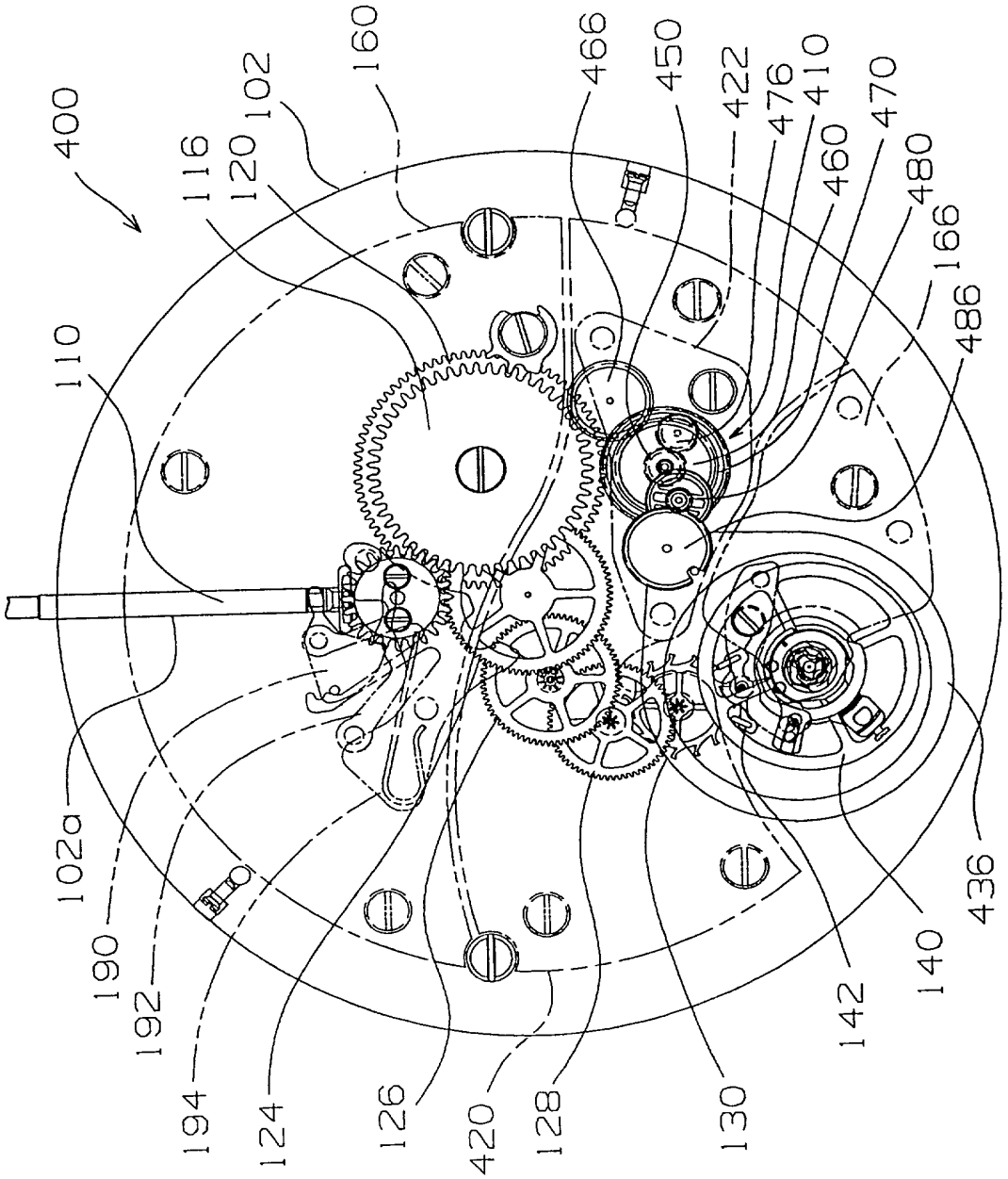
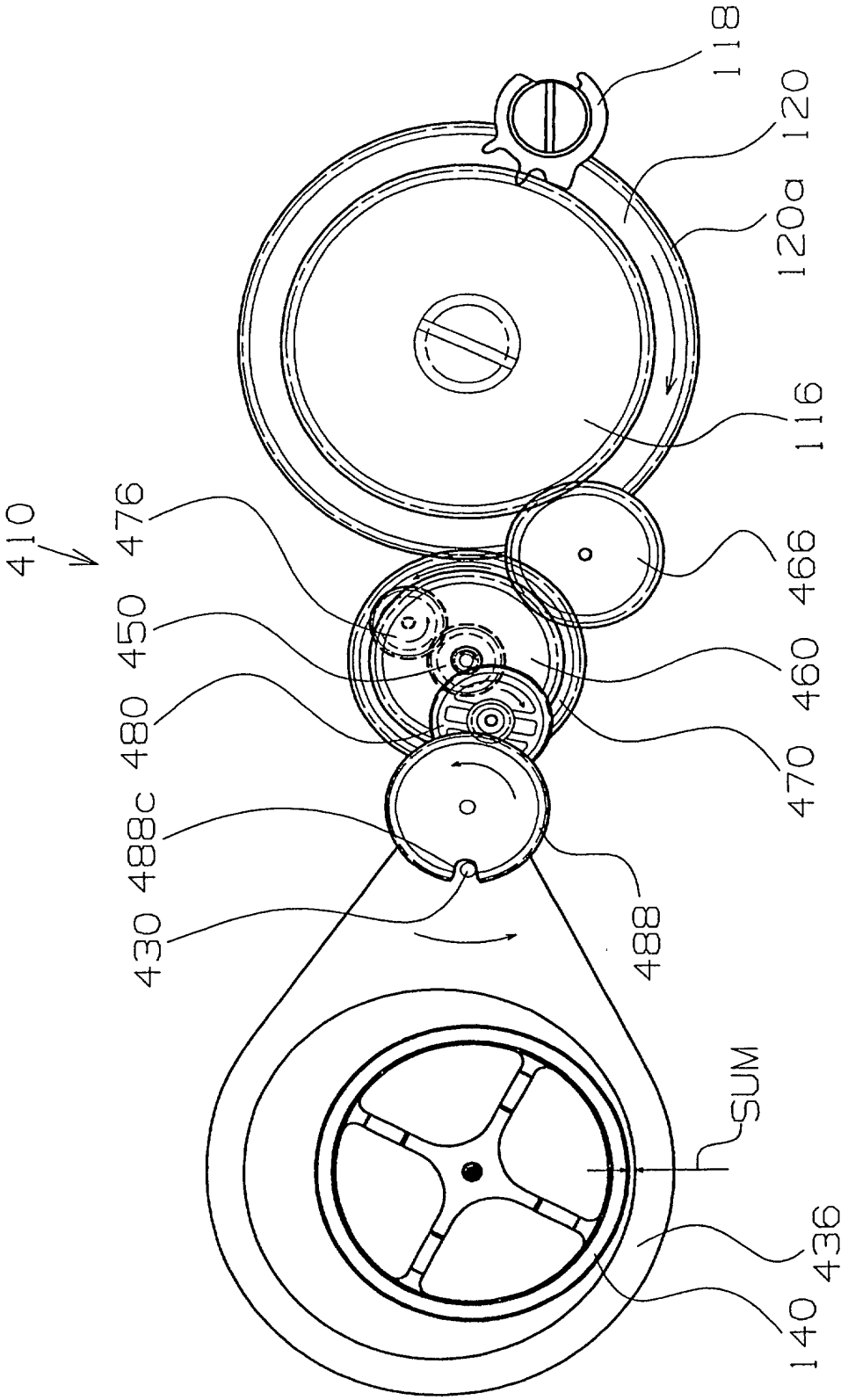

400
116
120
102
160
466
450
422
476
410
460
470
480
166
486
110
102a
190
192
194
124
126
420
128
130
142
140
436

FIG. 7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120a
116
466
460
470
488
SUM
436
140
410
476
450
480
488c
430

FIG. 8

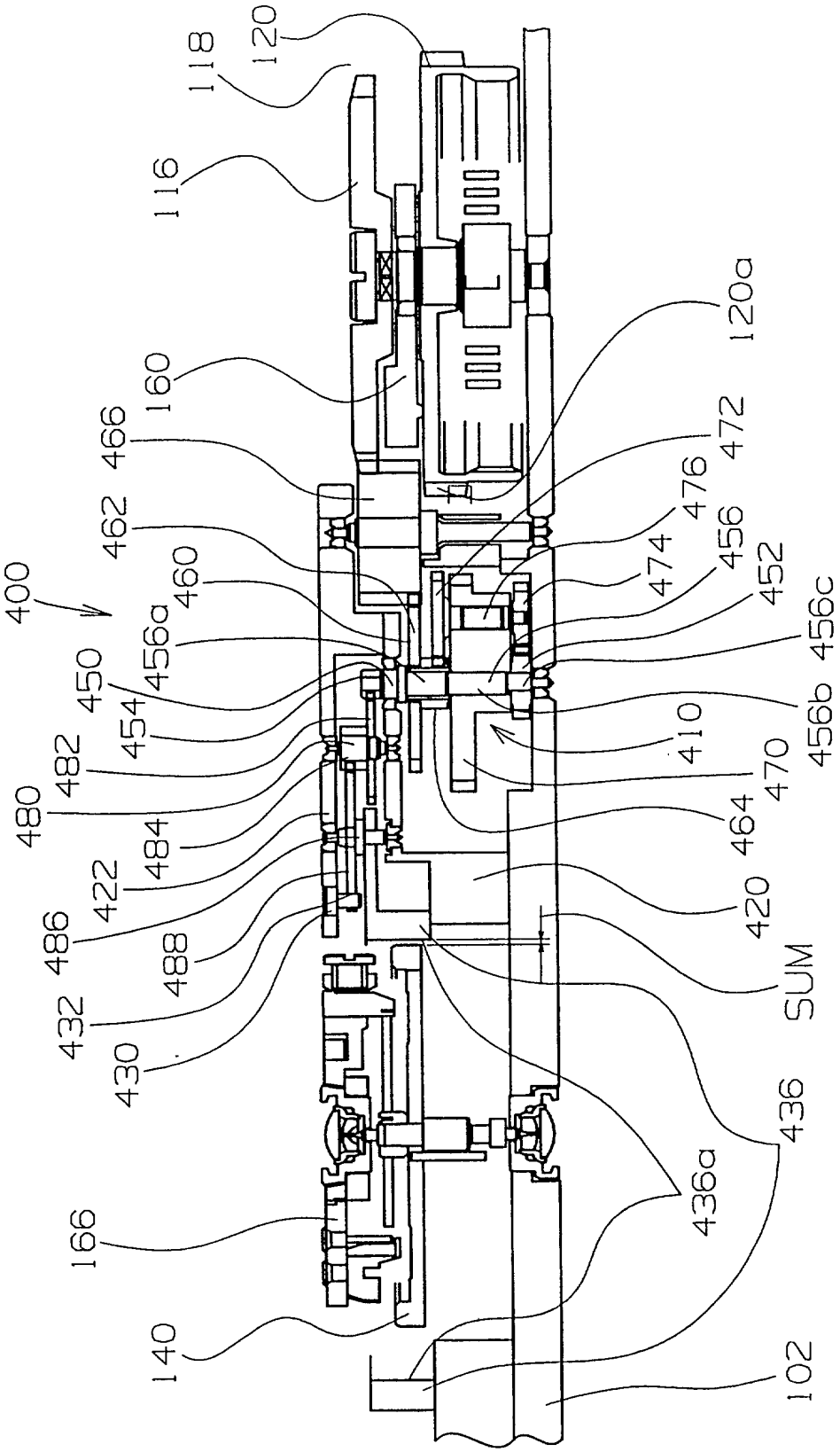


FIG.9

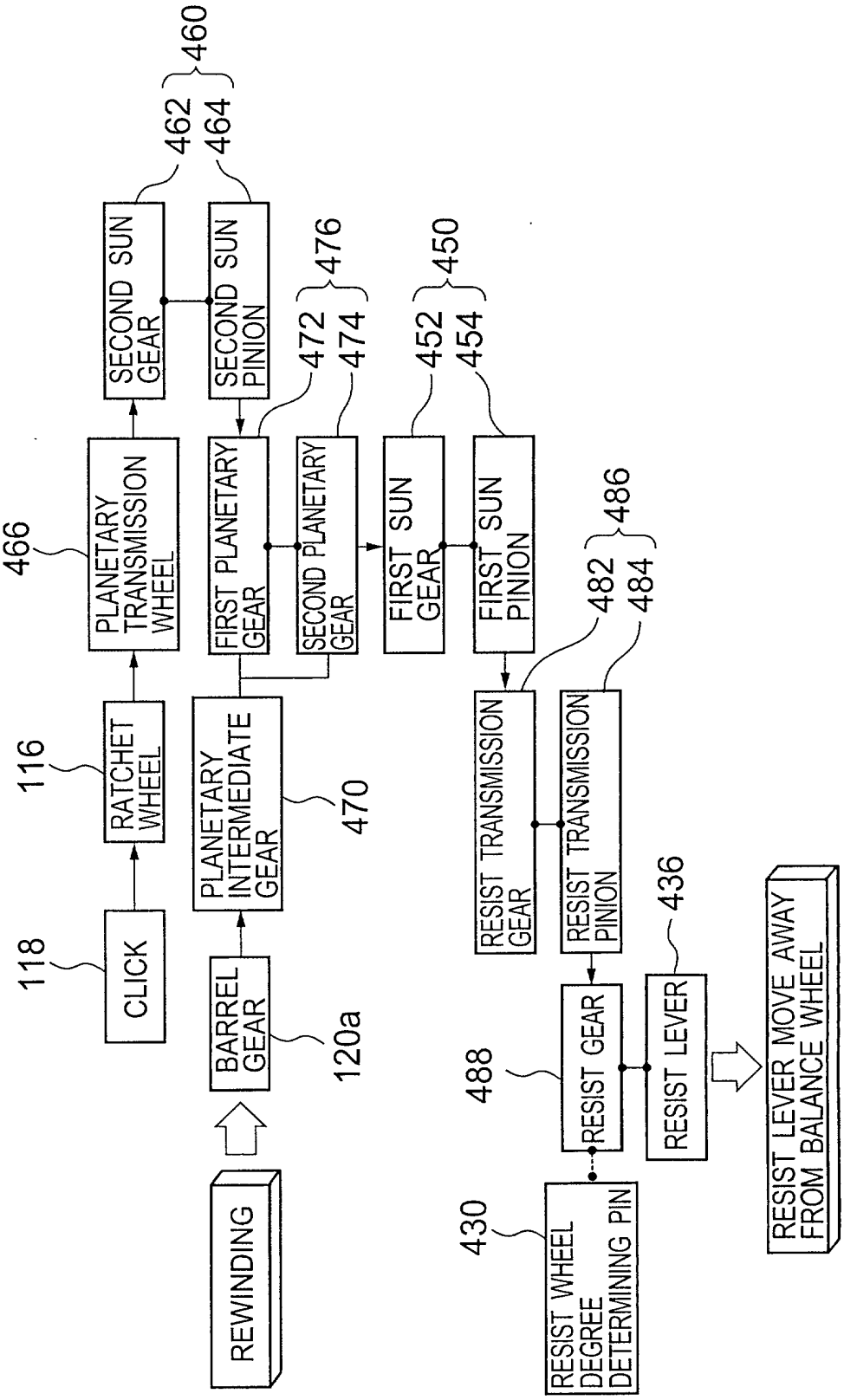

REWINDING
CLICK
118
RATCHET WHEEL
116
BARREL GEAR
120a
PLANETARY INTERMEDIATE GEAR
470
PLANETARY TRANSMISSION WHEEL
466
FIRST PLANETARY GEAR
472
SECOND PLANETARY GEAR
474
476
SECOND SUN GEAR
462
SECOND SUN PINION
464
460
FIRST SUN GEAR
452
FIRST SUN PINION
454
450
RESIST TRANSMISSION GEAR
482
RESIST TRANSMISSION PINION
484
486
RESIST GEAR
488
RESIST LEVER
436
RESIST WHEEL DEGREE DETERMINING PIN
430
RESIST LEVER MOVE AWAY FROM BALANCE WHEEL

FIG. 10

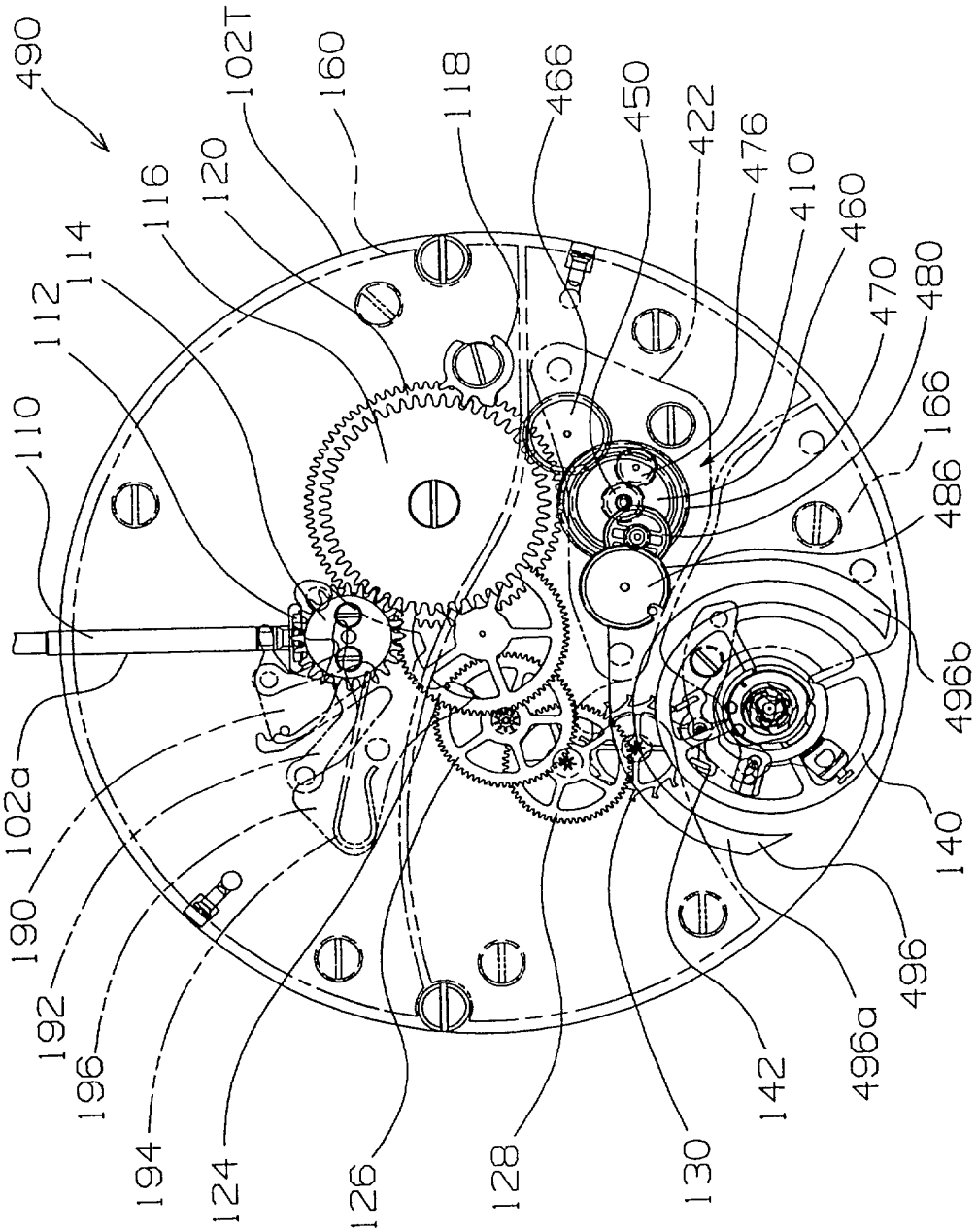

490
102T
160
118
466
450
422
476
410
460
470
480
166
486
496b
140
496
496a
142
130
128
126
124
194
196
192
190
102a
110
112
114
116
120

FIG. 11

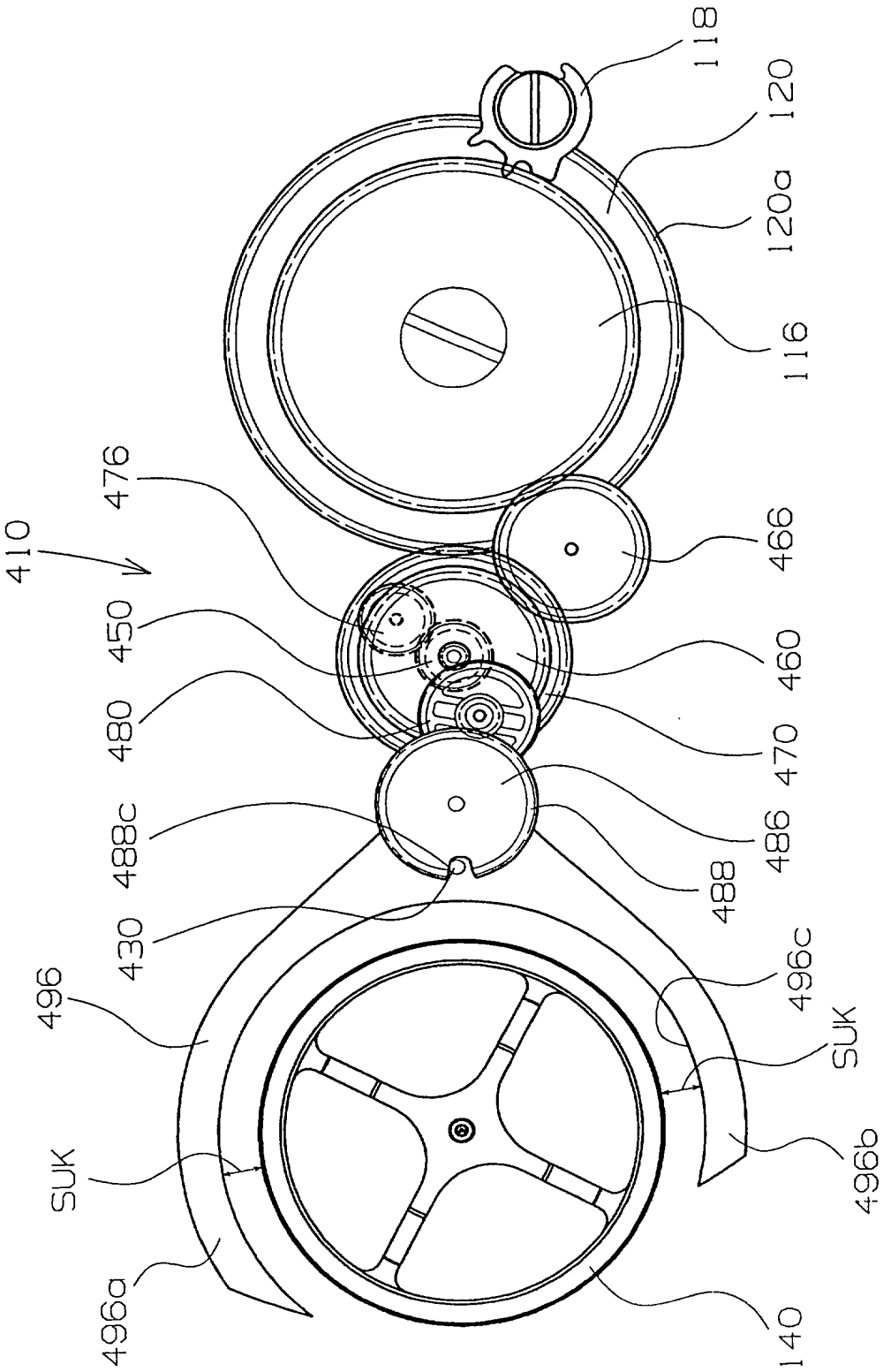

118
120
120a
116
476
410
466
450
460
480
470
488c
486
488
430
496c
496
SUK
SUK
496b
496a
140

FIG. 12

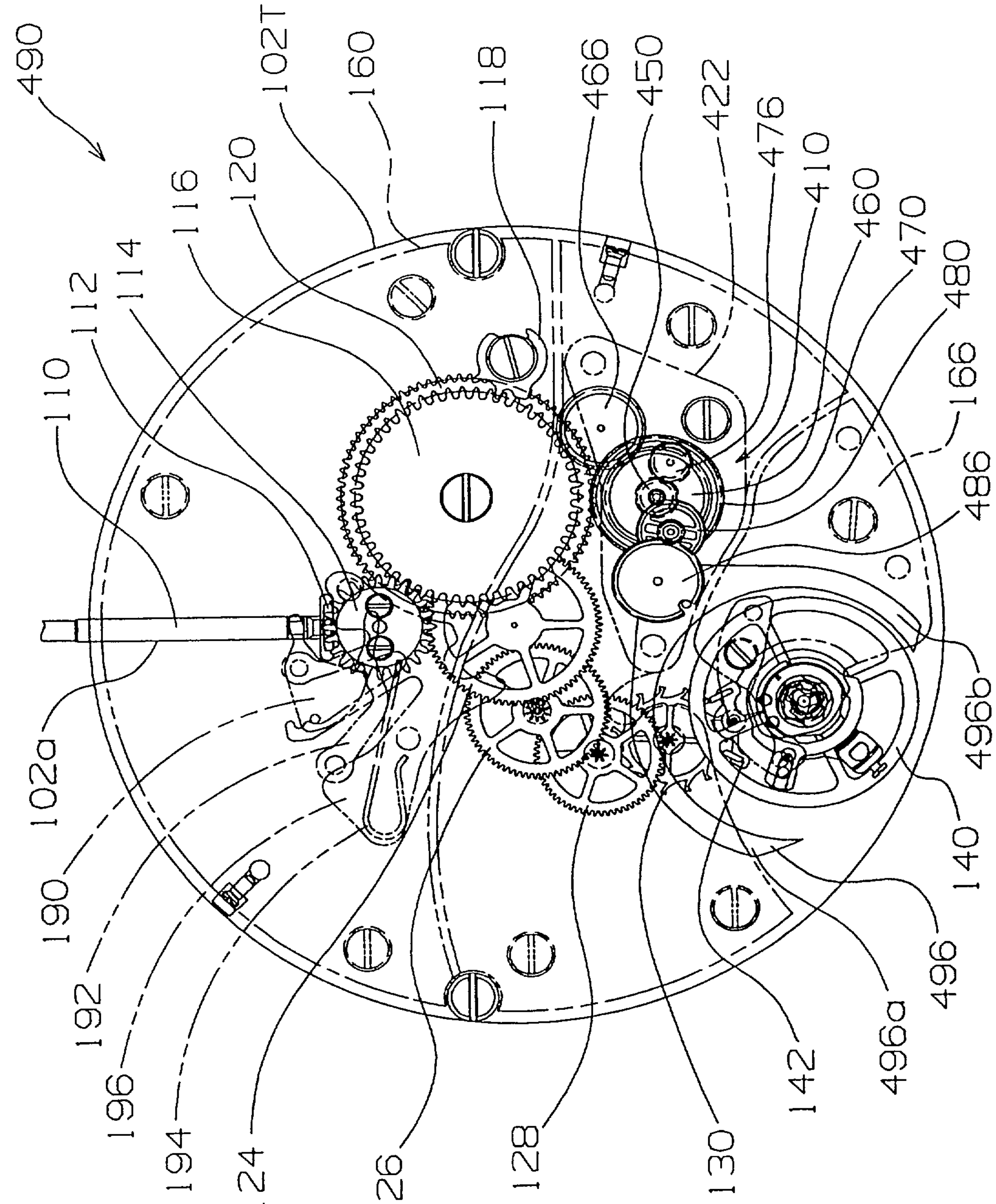

490
102T
160
118
466
450
422
476
410
460
470
480
166
486
496b
140
496
496a
142
130
128
126
124
194
196
192
190
102a
110
112
114
116
120

FIG. 13

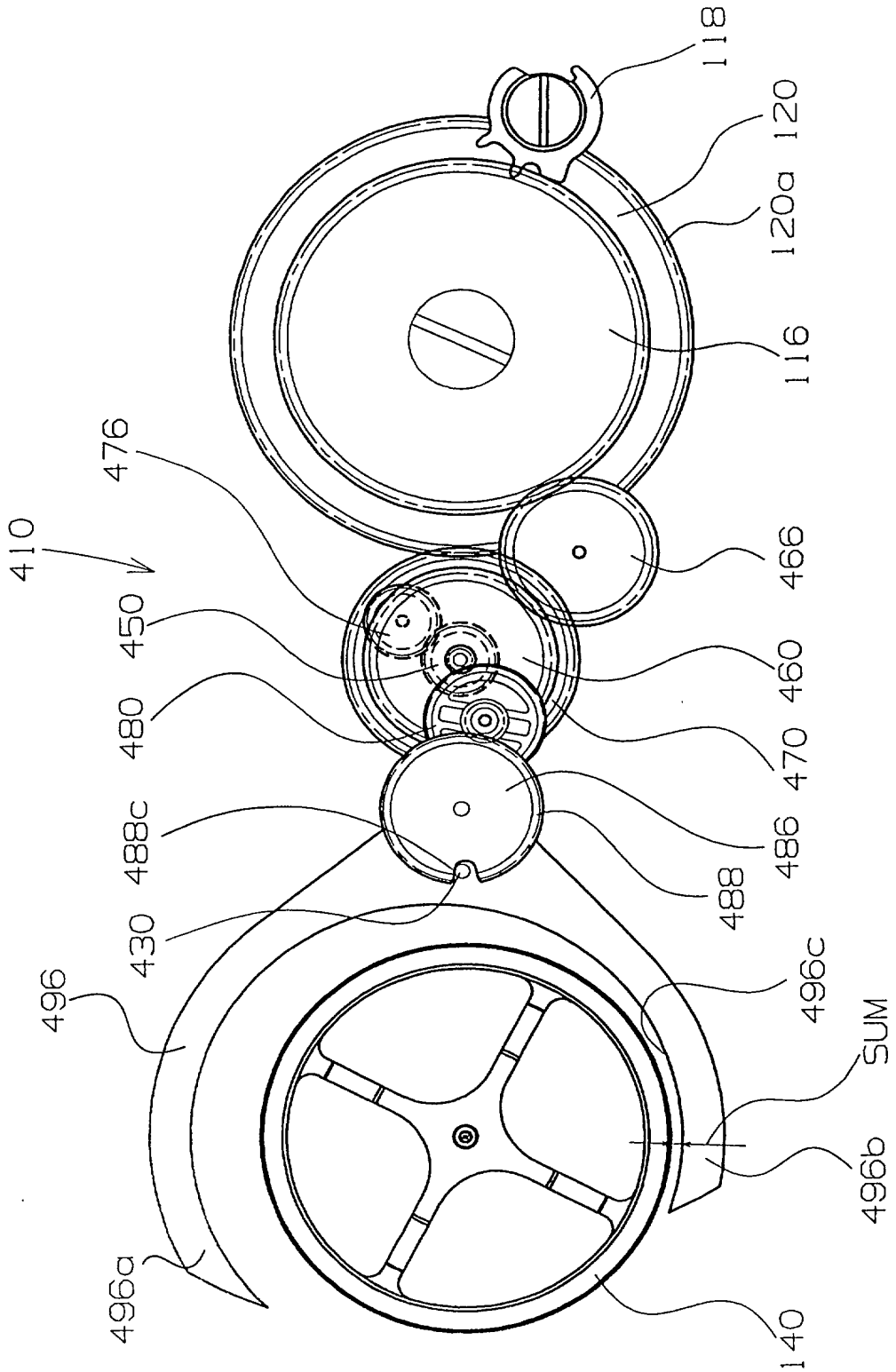

118
120
120a
116
476
410
466
450
460
480
470
488c
486
488
430
496
496c
SUM
496b
496a
140

FIG.14

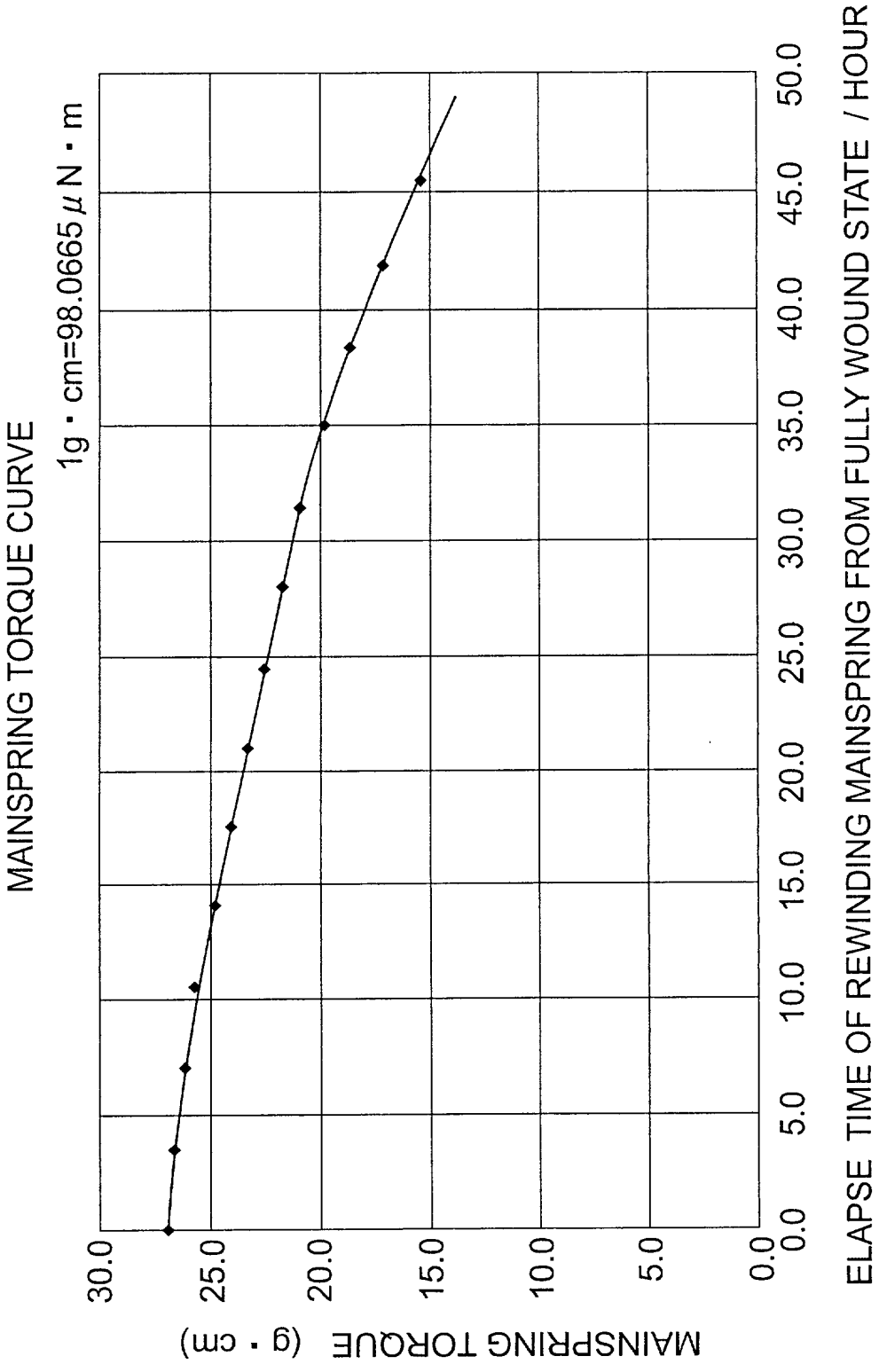

MAINSPRING TORQUE CURVE
1g・cm=98.0665μN・m
MAINSPRING TORQUE (g・cm)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
ELAPSE TIME OF REWINDING MAINSPRING FROM FULLY WOUND STATE / HOUR

FIG.15

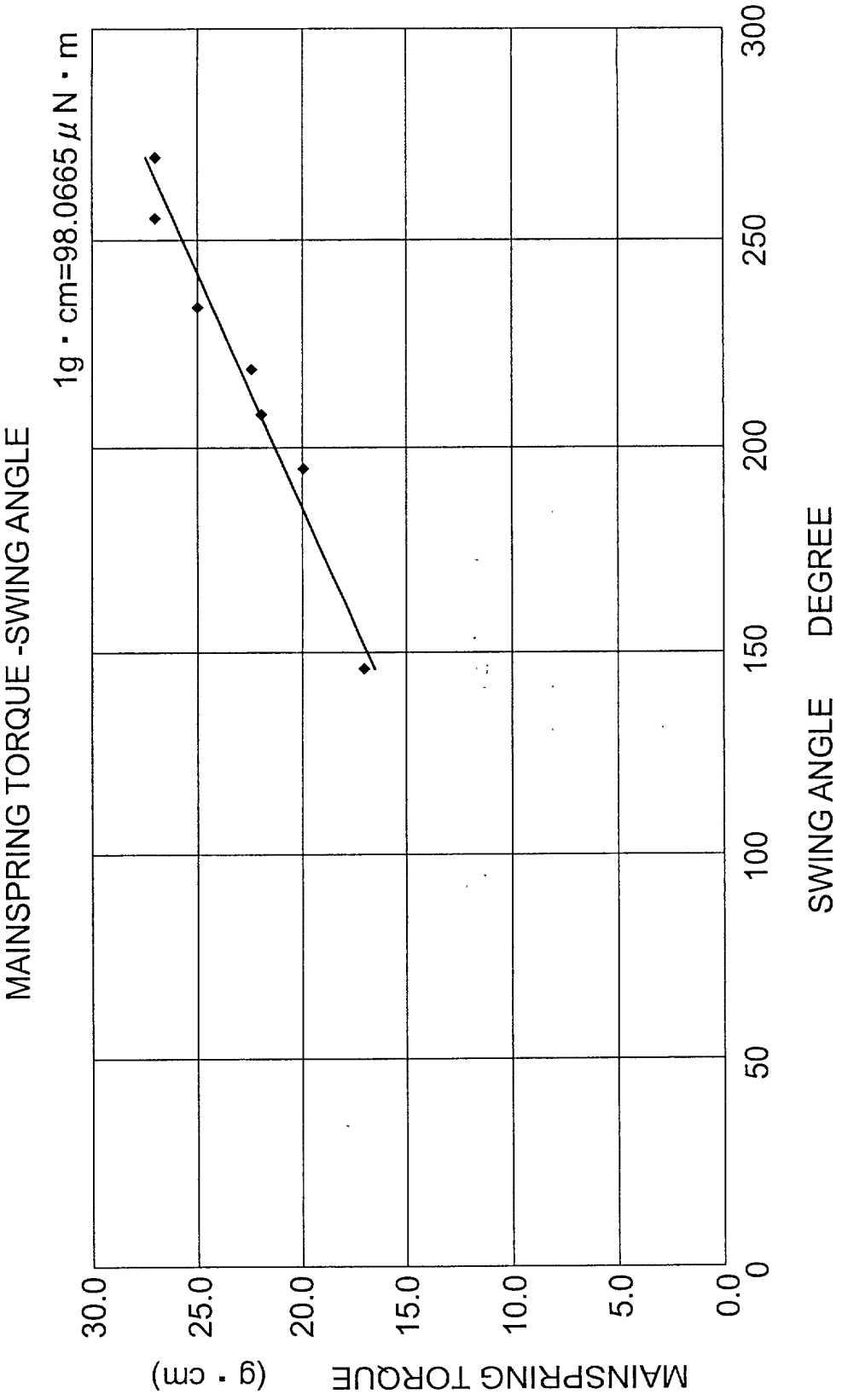

MAINSPRING TORQUE -SWING ANGLE
1g・cm=98.0665μN・m
MAINSPRING TORQUE (g・cm)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
50
100
150
200
250
300
SWING ANGLE DEGREE

FIG.16

TRANSITIONAL CHANGE OF INSTANTANEOUS RATE BY SWING ANGLE

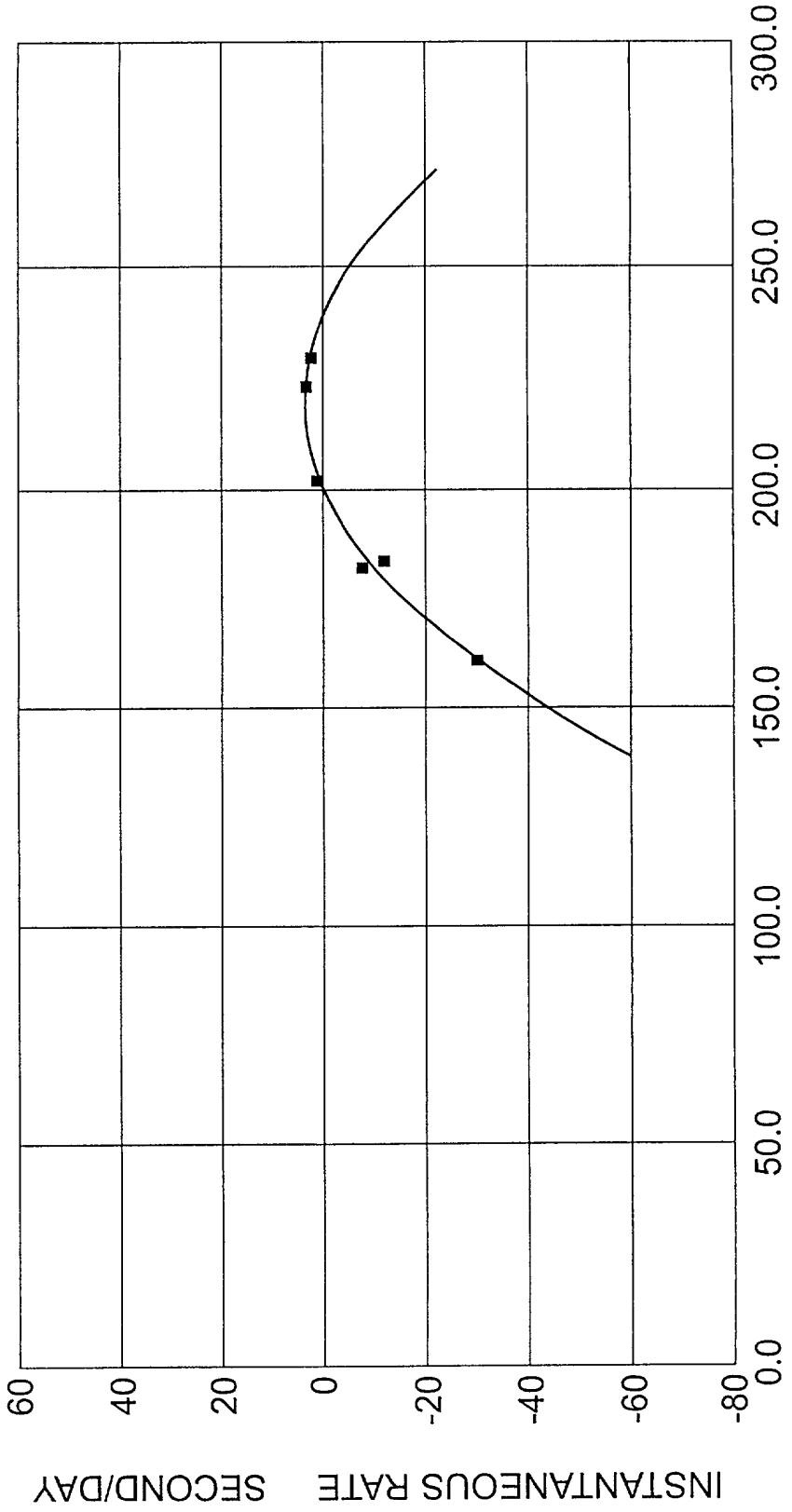


FIG. 17

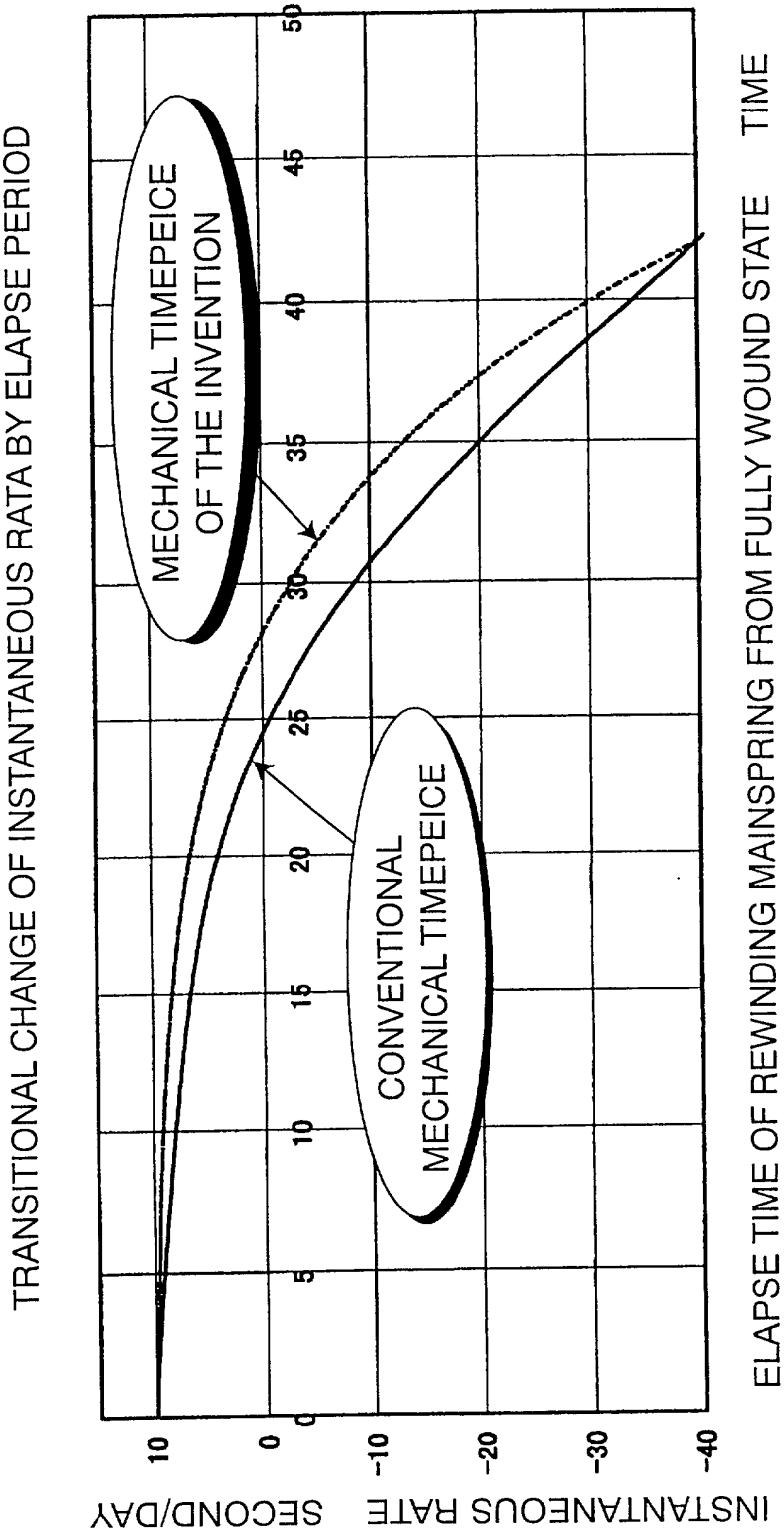

TRANSITIONAL CHANGE OF INSTANTANEOUS RATA BY ELAPSE PERIOD
MECHANICAL TIMEPEICE OF THE INVENTION
CONVENTIONAL MECHANICAL TIMEPEICE
INSTANTANEOUS RATE SECOND/DAY
10
0
-10
-20
-30
-40
0
5
10
15
20
25
30
35
40
45
50
ELAPSE TIME OF REWINDING MAINSPRING FROM FULLY WOUND STATE TIME

FIG. 18

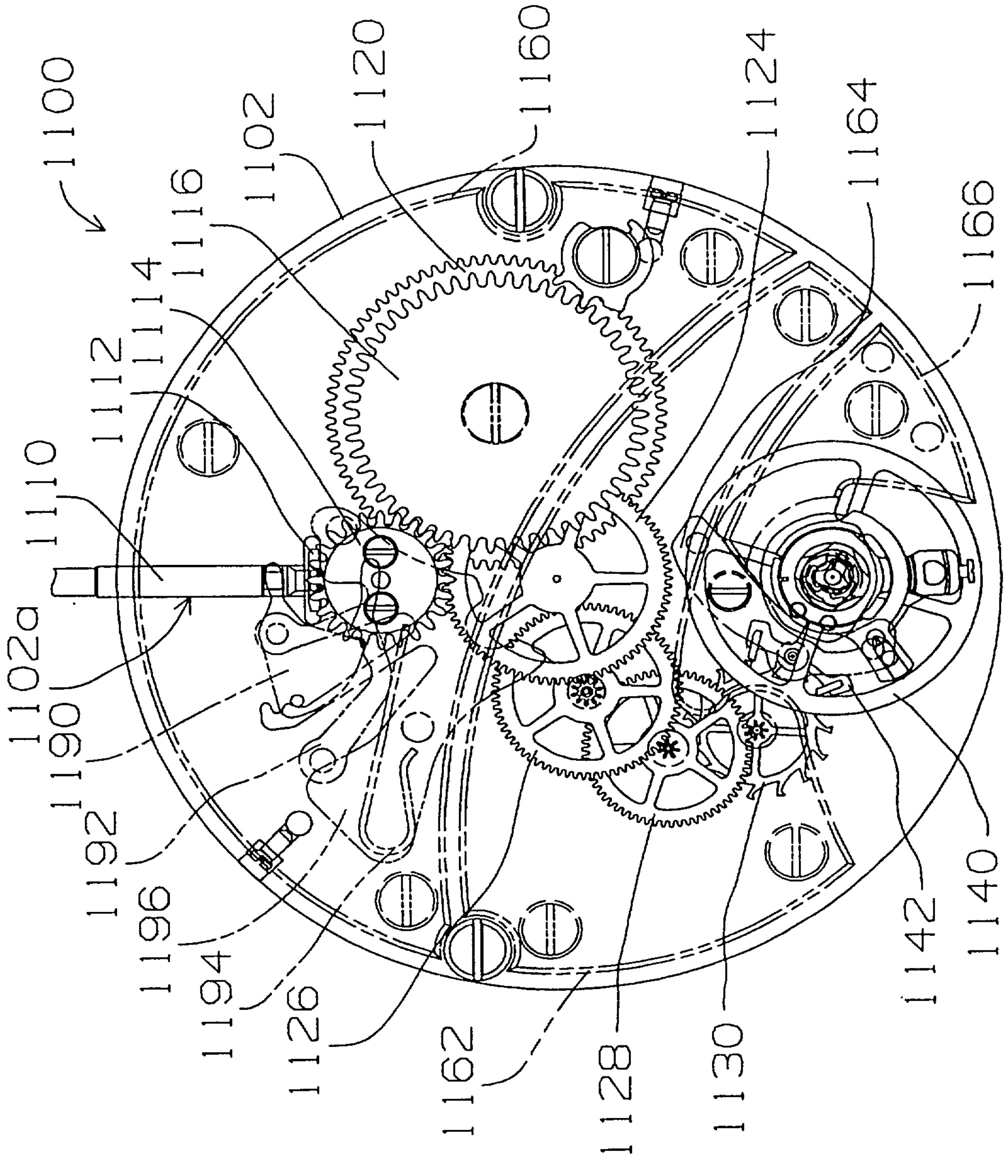
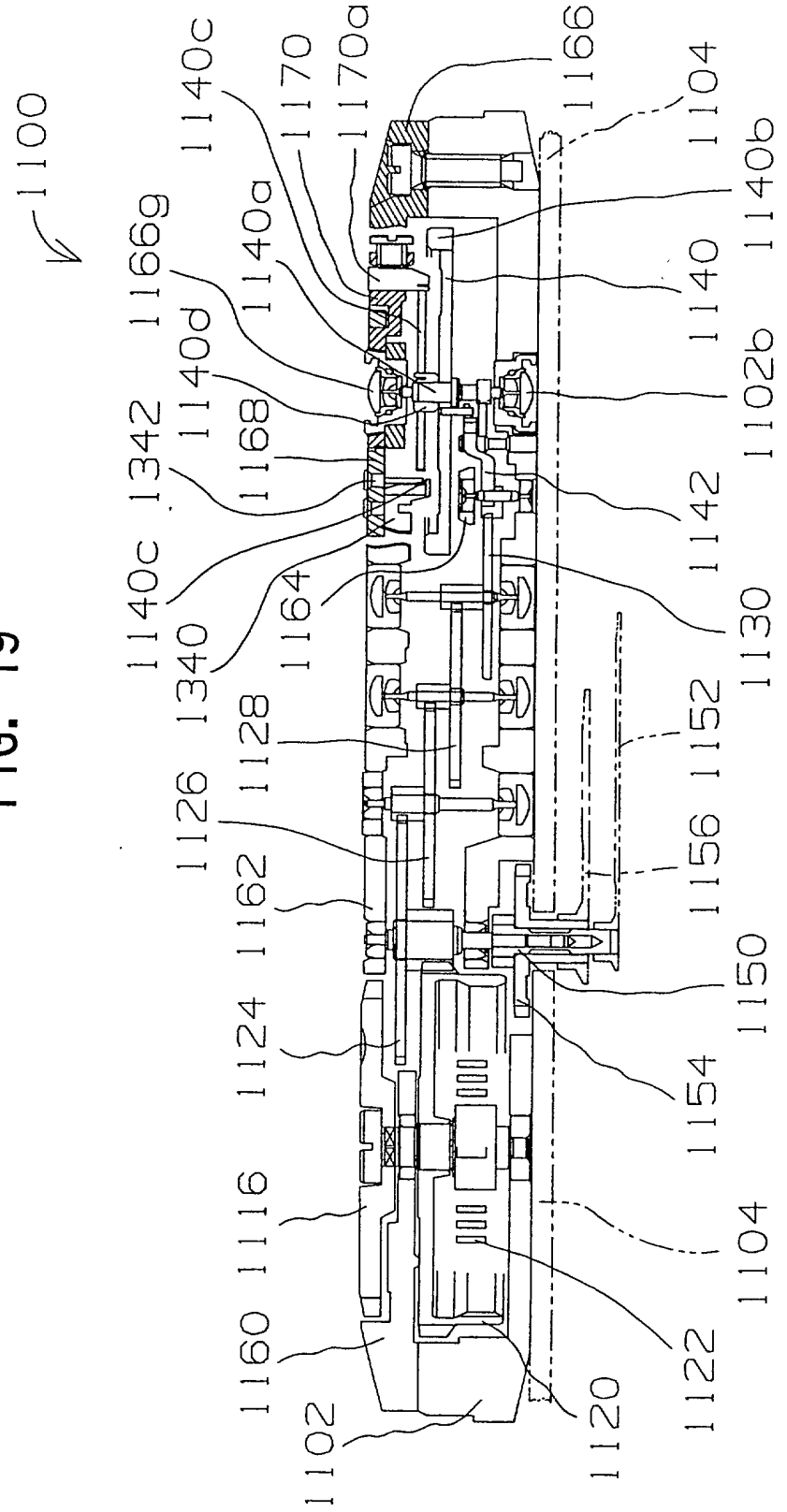

1100
1102
1120
1160
1124
1164
1166
1116
1114
1112
1110
1102a
1190
1192
1196
1194
1126
1162
1128
1130
1142
1140

FIG. 19


1100
1140c
1170
1170a
1166
1104
1140a
1140
1140b
1166g
1140d
1102b
1342
1168
1142
1140c
1164
1130
1340
1128
1152
1126
1156
1162
1150
1124
1154
1116
1104
1160
1122
1102
1120

99-355

DECLARATION FOR PATENT APPLICATION

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name; I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MECHANICAL TIME PIECE HAVING BALANCE ROTATIONAL ANGLE CONTROL MECHANISM as described and claimed in PCT/JP99/04077 Filed July 29,1999

the specification of which (check one); ☐ is attached hereto; ☒ was filed on March 28, 2001 as Application Serial No. 09/806,290 and was amended on (or amended through)_____(if applicable). I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment(s) referred to above. I acknowledge the duty to disclose information which is material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56(a). I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed Yes	Priority Claimed No
			☐	☐
			☐	☐
			☐	☐
			☐	☐
			☐	☐

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial No.)	(Filing Date)	(Status - Patented, Pending or Abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY

I (we) hereby appoint Bruce L. Adams, Registration No. 25,386, Van C. Wilks, Registration No. 25,027 and Franco S. De Liguori, Registration No. 36,497 whose post office address is: Adams & Wilks, 50 Broadway, 31st Floor, New York, New York 10004, as my (our) attorneys with full power of substitution and revocation, to prosecute this application, and to transact all business in the United States Patent and Trademark Office connected therewith.

Full Name of First or Sole Inventor	Citizenship
Takashi TAKAHASHI	Japan
RESIDENCE Address - Street	**POST OFFICE Address - Street**
c/o SEIKO INSTRUMENTS INC. 8, Nakase 1-chome, Mihama-ku	same as residence address
City (Zip)	**City (Zip)**
Chiba-shi, Chiba 261-0023	
State or Country	**State or Country**
Japan	
Date	**Signature**
May 24, 2001	Takashi TAKAHASHI

☒ See second page for additional joint inventors.

Second Joint Inventor, if any	Citizenship
Takeshi TOKORO	Japan
RESIDENCE Address - Street c/o SEIKO INSTRUMENTS INC. 8, Nakase 1-chome, Mihama-ku	POST OFFICE Address - Street same as residence address
City (Zip) Chiba-shi, Chiba 261-0023	City (Zip)
State or Country Japan JPX	State or Country
Date ✓ May 24, 2001	Signature ✓ Takeshi Tokoro

Third Joint Inventor, if any	Citizenship
RESIDENCE Address - Street	POST OFFICE Address - Street
City (Zip)	City (Zip)
State or Country	State or Country
Date ✓	Signature ✓

Fourth Joint Inventor, if any	Citizenship
RESIDENCE Address - Street	POST OFFICE Address - Street
City (Zip)	City (Zip)
State or Country	State or Country
Date ✓	Signature ✓

Fifth Joint Inventor, if any	Citizenship
RESIDENCE Address - Street	POST OFFICE Address - Street
City (Zip)	City (Zip)
State or Country	State or Country
Date ✓	Signature ✓

☐ See third page for additional joint inventors.